PROCEEDINGS:

International Symposium On Crisis Management

Mine Fires, Explosions and other emergencies

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FOREWARD

A symposium was held on October 19, 20 and 21, 1982, at Sydney, Nova Scotia, to examine various management structures in place to handle fires, explosions and other mine emergencies. The four participating organizations sponsoring the symposium were:

The Federal Departments of Labour and Energy, Mines and Resources

The Nova Scotia Department of Mines and Energy

The Cape Breton Development Corporation.

Ten papers were presented at the symposium. The papers are reproduced in this volume in the order of their presentation. Following the formal presentation, a panel discussion was held.

The entire proceedings were recorded on tape. The questions and answers at the end of the individual presentations and the panel discussion were transcribed from those tapes, with minor editorial changes.

The Organizing Committee wishes to take this opportunity to express thanks to each author. Without the authors' efforts, the symposium would not have been possible.

Organizing Committee
March, 1983

OPENING REMARKS

HONOURABLE RON BARKHOUSE
MINISTER OF MINES AND ENERGY
PROVINCE OF NOVA SCOTIA

Mr. Chairman, it is a pleasure to have been invited to participate in the opening of this International Symposium on Crisis Management, Mine Fires, Explosions and other Emergencies. I would first of all like to bring greetings to you from the Government of Nova Scotia and to personally extend a sincere welcome to those who are visiting from other parts of Canada and other countries.

It is most unfortunate that Steve Rankin, the President of the Cape Breton Development Corporation, could not be with us today. We wish Steve, as we wish Tommy Baldwin, the Mine Manager at Prince Mine, each a speedy and full recovery and hope that they are back on the job in the very near future.

Mr. Chairman, the necessity of this Symposium dealing with mine emergencies is evident from past experience and brought home to us this past week when we had a fire in the No. 26 Colliery at Glace Bay. Fortunately, as a result of quick action and a co-operative effort, a potentially serious situation was averted. The sponsors of this Symposium are to be congratulated for organizing the event and for attracting a number of outstanding speakers from Australia, France, the United States, West Germany, the United Kingdom and Poland, who will provide you with their experience and expertise in dealing with mine emergencies in their countries.

As a result of this exchange of information on what is happening in other parts of the world, we in Nova Scotia will be better able to improve our planning for mining emergencies that could possibly occur in the years ahead. We sincerely hope that our visitors will also benefit from the exchange of information on how to plan and organize to cope with such emergencies.

As many of you know, mining has been an integral part of the history of Nova Scotia for more than two centuries. Throughout the years, it has been a mainstay of the Provincial economy, in particular, here in Cape Breton. However, Mr. Chairman, the history of mining has been scarred by disasters which has resulted in the loss of many lives and the associated mines. Two very notable mining disasters which occurred on the mainland in the Town of Springhill in 1956 and 1958 claimed many lives and eventually brought about the closure of two coal mines resulting in severe economic hardships for the community and its people. In more recent years, an accident at No. 26 Colliery in 1979 resulted in the death of twelve miners and injuries to several others.

We recognize mining as a dangerous occupation and must always keep that foremost in our minds and make every possible effort to reduce the hazards for the men that have to work below the surface of the earth. We in Nova Scotia, are aware of the needs for improved safety and we are making every effort possible to train and equip our people in the mining industry with the most up-to-date training methods and equipment to deal with accidents when they arise.

Since the energy crisis in the early 1970's, coal has become the corner stone of this Government's energy policy. With this new emphasis on coal, more mines will be open providing additional employment and over the next few years, the increased activity in the mining field, requires the safety aspect of coal mining to assume greater importance than ever before. We are proud with our involvement in mine rescue and pleased with the co-operation we receive from the mining companies and in particular, the Cape Breton Development Corporation. Each of the underground mines, has a Mine Rescue Station and the Department of Mines and Energy has set up a central Mine Rescue Station in Stellarton, on the mainland.

Our personnel are responsible for co-ordinating mine rescue training and co-ordinating the mine rescue capabilities of the various mines in the Province. Each year, competitions are held among the various rescue teams to test their rescue techniques and to hone their rescue skills. While safety is an every day affair, we must be prepared for the possible mishap that becomes a crisis situation. In other words, while these programs are good in themselves, they are not an end to themselves. The day to day safety procedures are most important. However, greater effort must be made to develope long range plans to deal with every type of mine emergency that might arise in the future.

While we recognize the importance of planning for emergencies, we also hope that we will never have to put these plans into operation. In Nova Scotia there are numerous agencies from Federal and Provincial Governments, as well as the private sector, who are involved in various types of mining. Since there are many separate groups involved, co-operation in dealing with emergencies is essential.

This Symposium, which has been arranged by the Cape Breton Development Corporation, Labour Canada, the Federal Department of Energy, Mines and Resources and our own Department of Mines and Energy, is certainly an excellent first step along the road to co-operation and mutual support.

I wish you well in your deliberations, and I hope that from your discussions over the next two days a new spirit of interest and approaches will result which will enable us to better prepare for mine emergencies in the years ahead. I offer the full co-operation of my department since we share the same ultimate goal; namely, to elimate, if possible, and at least reduce the impact of mine disasters as well as loss of life, which so often is a part of such mishaps.

Thank you very much.

WELCOME TO DELEGATES

A. ROY MacLEAN
VICE-PRESIDENT, CORPORATE PLANNING
CAPE BRETON DEVELOPMENT CORPORATION

Mr. Chairman, Mr. Minister, gentlemen, I would like to sincerely welcome you to this symposium on crisis management on behalf of the President of the Cape Breton Development Corporation who was unable to be here today because of a most unfortunate accident in one of our mines.

I doubt if any of us here, whether we are intimately concerned with the management of crisis or whether we, like all men, are potential victims of it can possibly underestimate the value of your expertise in this tremendously important phase of our industry. Had you arrived about a week ago, as the Minister has just said, you would have had a chance to see and perhaps participate in a mine fire which could have destroyed a very large mine in Glace Bay, if the people involved had not reacted properly and expertly to this major crisis situation. I think it was a tremendous effort last Tuesday which saved that mine and a lot of the people in this room who actually did it. While you are talking with them, you can learn a lot about what actually did happen and how they handled the situation. Maybe this symposium should have been held a week earlier.

Under these stress situations, such as the one the other night, everybody reacts in a different way. Some are cool, some get excited and some get just plain scared. I feel that it is your job to see that all these energies are controlled and channeled towards just one goal - the elimination of the crisis situation, with the least damage to life and property. An extension of this goal is the necessity to learn from these actual crisis, such as the one we just talked about and to develop procedures and regulations which can prevent the reoccurrence of such accidents. I am sure that we all learn from them but I am not so sure that we all transmit that which we learn so that other people in different areas can benefit.

Today, you will be examining the many factors of crisis management. Perhaps you will be measuring the costs of crisis, for that is a most reasonable and objective way of making comparisons and assessing consequences. But I would urge you to consider also that subjective element of human anguish which the Minister spoke of, which is never far off when there are mine fires, explosions and other emergencies. We must look at that aspect and try to minimize that as well.

Inevitably crisis occur because details were overlooked. It therefore follows that the management of crisis is ultimately the best management of your operation, for then there should be no crisis. But until that utopian day arrives, gentlemen, we must depend on you and your co-workers to react to the failure of others to perform their work properly.

May I conclude by wishing that your deliberations be fruitful, may the information you receive from each other prove to be of benefit to you in your work in the future and again I welcome you to Sydney and hope that your stay will be enjoyable.

CRISIS MANAGEMENT PREPARATION

BY

J. E. MERRETT, P. ENG.
CHIEF INSPECTOR OF MINES FOR
BRITISH COLUMBIA
(RETIRED)

CRISIS MANAGEMENT PREPARATION

The theme of this Symposium suggests to me subjective approaches to incidents of serious consequence to the safety of persons in or about a mine, to the protection of mining property during such occurrences, to a possible extended interruption of operations at a mine, or to a combination of any or all of these conditions. Inasmuch as my association with the mining industry since 1948 was as a member of the variously titled Department of Mines and Petroleum Resources of British Columbia, from which I retired in 1977 as Chief Inspector, my relationship to incidents of crisis management at any mine was objective in nature. I therefore propose to briefly detail this period and to show how the information gained from these situations can be extended to assist in crisis management preparation long before the event occurs, and to the development of operational organizational plans to be invoked on the occasion of a crisis.

In the more than three decades spent with the Mines Inspection Branch I had an opportunity of being closely informed concerning several accident occurrences and other events resulting in crisis management action during that period. Additionally, I was made aware of all fatal and serious mining accidents which, while not necessarily invoking crisis management action, were events critical in the operation of a mine, and when classified on causal basis throughout the industry often indicated the necessity for critical action by the Mines Inspection Branch in order to avoid or reduce the repetition of such events.

The source of the accident and other information in this presentation was obtained from the Annual Reports of the Minister of Mines of British Columbia and is supplemented by my own observations.

UNDERGROUND MINE RESCUE TRAINING IN METAL MINES

On Monday, August 18th, 1947, three men were killed in an explosion of methane gas in the underground workings of the Pacific (Eastern) Gold Mine in the Bridge River area. These men were doing exploratory diamond drilling on 520 level at a point 1370 metres from the shaft station. On leaving their work place the previous Friday afternoon, they shut off the compressed air and the ventilating fan although they were aware methane was entering from two diamond-drill holes completed at that point. On returning to their work place on Monday, an explosion occurred.

As no mine rescue equipment or mine rescue trained personnel were available at the mine or at the two other large mines in the area,

a crew of rescue trained coal miners and self-contained breathing equipment were flown in from the Nanaimo Mine Rescue Station on Vancouver Island. This rescue crew reached the explosion site about 18 hours after the blast occurred. The subsequent investigation indicated sufficient methane had accumulated over the weekend shut down to have formed an explosive plug along 150 to 180 metres of tunnel. The evidence at the site indicated the ignition was probably caused by an arc flash on a battery locomotive controller when swung into reverse to provide a braking effect on the locomotive.

Subsequent to this incident an Order-in-Council was approved regulating mining procedures in metal mines when methane gas was encountered, but more important, soon after, the Metalliferous Mines Regulation Act was amended to require that when considered necessary by the Inspector of Mines, mine rescue equipment was to be provided and maintained at underground metal mines and men were to be trained in its use and in underground rescue procedures.

It is to be noted these requirements had been mandatory in coal mines in British Columbia since 1910, following the explosion of October 5th, 1909, in No. 2 West, Extension Colliery at Nanaimo where 32 men lost their lives. Since then and up to July 1st, 1982, 5,472 persons have been so trained and qualified for Certificates of Competency in Mine Rescue Training.

Records show that the first metal miners to receive Certificates were from Anyox in 1917, and that in 1930, the Consolidated Mining and Smelting Company equipped a mine rescue station at the Sullivan Mine and commenced the training of men. Continuously since then this company has maintained training at this mine, which during the 1950's and 1960's proved invaluable to them, when fires from spontaneous ignition occurred in the broken ore produced in large pillar blasts. In spite of the high temperatures developed and of the heavy concentrations of sulphur dioxide, which dissolved the aluminum blades of the ventilating fans (until rubber coated), and also charred the ties and timbers, properly trained mine rescue crews successfully contained the highly critical situation with but minimal interference with normal operations. It would be gratifying to say this control had been achieved without accident incident but unfortunately on May 15th, 1963, two men were severely burned by an outrush of hot air and dust from a drawpoint when an ore hangup dropped. One of the men, whose body area had been burned up to 40 percent, succumbed 24 days later. This same company, the name of which was subsequently changed to Cominco Ltd., established mine rescue training at Bluebell Mine, Riondel, soon after it reopened in 1949. This action also proved fortuitous, because subsequently, when large inflows of mine water, heavily charged with carbon dioxide were encountered and continued without abatement throughout the life of the mine, the operator was able to cope with the emergencies created because of irrespirable atmospheres developed in various parts of the mine. These two examples of prior emergency preparation demonstrate how the operator successfully handled critical management situation.

To assist in maintaining high levels of interest and competency in mine rescue training, the Provincial Government has, since 1914, issued through the Mines Department, grants to district mine safety associations to promote annual competitions between teams from different mines within the districts. In 1956, this was expanded to include a Province-wide competition and, finally at the invitation of British Columbia, the first Canada-wide competition was held in Trail, B.C., in 1967. Currently Nova Scotia, New Brunswick, Saskatchewan, Alberta, British Columbia, Yukon and the Northwest Territories participate in this annual event which has stimulated interest and standardized mine rescue procedures in them.

On May 2nd, 1972, ninety-two men died in a major fire disaster at the Sunshine Mine, of the Sunshine Mining Co., Kellog, Idaho, and in response to a call from that mine for assistance, two mine rescue teams from the Fernie area coal mines, one team from the Sullivan Mine, two Inspection Branch Rescue Coordinators and one Inspector of Mines immediately travelled to the Sunshine Mine to join in the rescue efforts. The performance of this group in the search and recovery operations so impressed the mining operators in that area that they have now adopted the rescue training procedures used by the Canadian teams and have entered mine-rescue teams in some of the district competitions in B.C.

SURFACE MINE RESCUE TRAINING

In 1959, the Provincial Government received a petition from one of the miners' unions requesting that miners be certified as tradesmen, and in support of the petition, asserted that by being so qualified safety in mines would be improved. The investigation made concerning this request concluded that the assertion was not valid as it appeared workmen observed safety practices only to the extent demanded of them by their immediate supervisor. In consequence, the Metalliferous Mines Regulation Act was amended in March, 1960, requiring underground shiftbosses to be qualified by certification. This certification obliged them to pass an examination on safe mining practises and their knowledge of the Metalliferous Mines Regulation Act as it pertained to underground mining. In addition, they were required to be in possession of a Blasting Certificate, a Mine Rescue Certificate, a valid First-Aid Certificate and to give proof of adequate mining experience. This new regulation was not received with any great enthusiasm by mine operators, by the then current shiftbosses, or by the members of the Inspection Branch who had been appointed to the newly formed Board of Examiners. The mine operators considered this regulation an intrusion on their right to determine who were qualified to be shiftbosses at their mines. The shiftbosses did not relish the thought of the studying necessary to qualify, while the members of the Board of Examiners faced a lot of additional work in the preparation, invigilation, and marking of the examinations.

After the initial rush to be qualified was over and the process became routine and less onerous, mine management found there had been no interference with their choice of supervisors and that the studies by the shiftbosses made them much more knowledgeable concerning their responsibilities in their observance of the Metalliferous Mines Regulation Act and thus were better qualified.

In 1968, some of the managers of the openpit mining operations requested certification be extended to mine shiftbosses at their operations. In addition it was requested some form of safety training be given, comparable to mine rescue training underground. As no specific suggestions concerning the type of training to be given were received, a survey was made covering the previous 20 years concerning all fatal and serious accidents and the dangerous and/or unusual occurrences on the surface at mines, to determine the type of training which would most suit the needs of the openpit mining operations. Having made this determination some of the Mine Inspectors, together with all the Rescue Coordinators, jointly prepared a course of safety instruction concerning the following topics:

(a) Recovery of victims of electric shock and their First-Aid treatment;

(b) The recognition of poisonous and/or suffocating gas occurrences at surface mining installations and the use of respiratory protective equipment for these occurrences;

(c) Fire fighting and rescue procedures;

(d) Cold weather problems such as avalanche search and rescue, ice travel, wind chill and hypothermia;

(e) Rescue of injured people from vehicles;

(f) Rescue of people buried in ore bins or stockpiles;

(g) Rope rescue work.

Surface mine rescue training commenced in 1969 and since that time 3,886 Certificates of Competency in Surface Mine Rescue Training have been awarded.

This course has been very well received by all who have taken it and the only complaints registered concerning it is that it should be longer. However, it is believed that with the training received the individual could improve their proficiency with continuing practice on their own. Many persons not employed in the mining industry on learning the course was being presented in their vicinity arranged to attend and qualified for certification. This group has included many police, firemen and nurses and it has provided training for local search and rescue crews.

Inspection staff Rescue Coordinators have, in addition to providing training within the Province, travelled outside it on request to present this course in Alberta, the Yukon Territory, Idaho, and Wyoming. It is understood this course has been adopted in Alberta.

Surface mine rescue training has proven to be of considerable value in assisting management by having competently trained personnel available to render immediate service during an accident crisis. It was gratifying to learn that members of the third class given, after having had only one week of training in rope rescue work, efficiently and speedily removed an injured haulage truck driver trapped behind the steering wheel of his truck at a point about 5.5 metres above the ground.

SURVIVAL RESCUE TRAINING

Earlier mention has been made of the participation of mine rescue crews from southeastern British Columbia in the rescue attempt at the Sunshine Mine disaster in Kellogg, Idaho, in May, 1972. As a result of this disaster, the mine rescue and escape procedures were reviewed for all mines in British Columbia and there was some evidence that the possibility of a similar disaster for B.C. could not be ruled out. The Mining Regulation Acts dealing with safety in B.C. mines cover many items such as: the maintenance of secondary exists, the marking of secondary exits with signs or directional arrows; the posting of up-to-date mine plans showing the routes of egress from the active workings; the installation of refuge stations; the training of personnel in rescue procedures; the installation of fire suppression equipment; the reduction of fire hazards; the use of stench warning devices; the tally of workmen, etc; but what appeared to be lacking was the need for all mines to provide some rescue and escape information to underground personnel. Hence to insure all underground workers are made aware of and able to recognize underground fire hazards and to know how to protect themselves from these hazards by escape or by seeking refuge, an instruction manual was prepared by the staff of the Inspection Branch to provide such training in survival rescue procedures. This manual, completed in 1973, also includes a guide for planning mine emergency operational procedures for use during such incidents as fires, explosions, floods, or other major crises.

AVALANCHE CONTROL AND RESCUE

At about 10 a.m., Thursday, February 18th, 1965, an avalanche passed over the Portal Camp of Granduc Mines Limited, 38 kilometres northwest of Stewart, B.C. causing 26 deaths and the total destruction of a large portion of the camp.

The camp, at an elevation of 846 metres, was constructed on a knoll on the nose of a moraine on the west slope of Granduc Mountain, between the north and south limbs of the Leduc Glacier, the drainage from which

forms the Leduc River. This river joins the Chickamin River to empty into Behm Canal in Alaska. The camp had been established to accelerate the development of the mine workings about 1980 metres to the east, and with the adit portal to it being about 90 metres immediately below the camp. This portal is the west end of the 18.5 kilometre tunnel to the millsite at Tide Lake, east of Granduc Mountain.

Access to the Portal Camp from Stewart was by a lengthy, circuitous road which included considerable travel on glaciers, or by aircraft from Stewart to the airstrip on the north limb of the Leduc Glacier. This air service was frequently interrupted and often with prolonged delays because of adverse weather conditions at the Leduc airstrip where clouds and snowstorms are prevalent during the winter. The annual snowfall in this general area is quite excessive and has been recorded to average 28 metres at the Tide Lake Camp.

The profile of the mountain slope from the camp rises at 13 degrees for about 900 metres, then increases to 27 degrees for a further 1100 metres, although immediately east of the camp is a 45 metre wide depression in the moraine, 7.5 metres below camp level.

The avalanche which covered an area of at least 2.6 square kilometres started from a point about 760 metres in elevation above the camp and about 1.6 kilometres distant from it. It swept down across the south side of the moraine engulfing and totally destroying the kitchen building, coffee shop, the new mine dryhouse, a large powerhouse and compressor building, a large workshop and the former dryhouse. It also spilled around the tunnel portal but did not block it.

Although the camp power was cut off when the powerhouse was destroyed within minutes auxiliary power was connected to the radio transmitter and a distress signal sent to the Stewart office. Fortunately the medical doctor from Stewart was at the Portal Camp and had escaped the avalanche. He was thus able to give immediate treatment to twenty injured survivors brought to him.

Search and rescue efforts commenced as soon as possible by the available men in the camp and was later assisted by volunteers from Alaska, both by their Government and by private citizens, by the U.S. Coast Guard vessel "Cape Roman", by the British Columbia Civil Defense organization, and by members of the Mines Inspection Branch. The prevailing weather conditions prohibited access to and from Stewart so the injured and other survivors were evacuated to a base camp at the mouth of the Chickamin River and from there by plane or boat to Ketchikan in Alaska.

The search and rescue efforts in the portal area were commenced immediately inasmuch as those who had escaped were aware of the number and approximate work location of those who were missing. The situation at the camp was somewhat more confused because some of the individuals swept away were off duty and were in the coffee shop or somewhere around the camp. A search of the time sheets soon established the identities of

those missing but the whereabouts of some at the instant the camp was struck was not known thus making the search for them difficult. One survivor was found more than three days after the incident having been partly covered by a piece of plywood. The body of the final victim to be found was 122 days after the avalanche occurred.

It is also worthy of note that for the search crews plenty of accommodation was available but with the destruction of the kitchen buildings some difficulties were experienced in food supplies.

A snowslide and avalanche control consultant, M.M. Atwater, of Tahoe City, California was engaged by Granduc Mines Limited, to investigate the cause of the accident. He submitted the following:

> "There were abnormally low temperatures during the winter. High winds during the winter transported the snow into the slide area and formed hard slab snowpack. In February, large quantities of new snow and soft slab snow, modified by wind, were deposited upon the old unstable snow base. The sudden increase in pressure caused a chain reaction. The pressure collapsed the old hard slab under-layer of snow. The collapse caused a movement of snow in the top section of the snowfield which cascaded over the cliff side. The centre section of the mountain snowfield was released by the impact. The bottom section of the mountain snowfield now added itself to the torrent. The combined mass falling 760 metres vertically developed enough speed on a frictionless surface to run over the campsite with enough power to destroy it. It is estimated that the mass of moving snow which struck the camp contained 45,000 tonnes travelling over 160 kilometres per hour. It has been classified as a "Claimax Avalanche". This type of avalanche is rare as conditions are seldom present in the correct order. It does not normally repeat itself for years, but then again it could happen twice in one winter. It is emphasized that the set of conditions which could cause such an avalanche do not develop over a single night or in a single storm. The buildup can be recognized, and there are methods of breaking the sequence and destroying the conditions necessary to the formation of this type of avalanche."

This incident was, in the history of surface disasters at mining communities in B.C. third only to the nearly forgotten disasters at Britannia Mine. These were the mixed rock, snow, and mud slide of March 22nd, 1915 which destroyed Camp 1050 with the loss of the lives of between 50 and 60 men women and children, and of the Britannia Creek flood of October 28th, 1921, which struck the community of Britannia Beach and claimed the lives of 37 people. The Granduc incident was not the first disaster of this nature in B.C. inasmuch as an avalanche at the Taseko Mother Lode Mine in the south Chilcotin area in January 1935 wiped out the camp, killing the entire crew of seven men. Unfortunately there have been subsequent avalanches to that at Granduc, which have also claimed the lives of people at the mines, but none have been as severe as that at the Portal Camp.

The study of this and subsequent avalanches has indicated that when a mining camp has been or is about to be established where avalanches are known to occur, the installation should be located, constructed, protected, maintained and serviced in such a manner as to avoid or to minimize damage in the event of an avalanche. It is strongly recommended the mine operator should obtain the advice of a professional consultant knowledgeable in avalanche control. To insure such is obtained, if considered essential by the Inspector of Mines, Sections 6 of both the Coal Mines Regulation Act and the Metalliferous Mines Regulation Act provide the Inspector the necessary authority to require this. It is further recommended that where an avalanche hazard presents a continuing threat several employees should be trained in avalanche control and rescue procedures. In Canada, this training has been available on application to the Department of Northern Affairs and Natural Resources at Rogers Pass, B.C.

Additionally, in personal conversation with members of the Mines Inspection staff who were at Granduc during the search and rescue period, two recommendations were often repeated. These were first, as it was found the use of dogs to search for buried casualties was not too successful because of so much human scented debris in the snow having come from the demolished buildings and from the tracks of the searchers, it is recommended that all persons working in potential avalanche areas be equipped with pocket radio transceivers which should be in operation at all times to transmit when in the hazardous areas. Second, it was recommended that when it is necessary to move large quantities of snow while searching for buried victims this be done if possible with a bull-dozer or shovel loader both of which should only be used in conjunction with avalanche probes. It is believed that where this was done at Granduc some of the buried individuals recovered would have succumbed before being reached by hand shovelling.

It is gratifying to report that subsequent to taking the avalanche search and rescue training at Rogers Pass, one of the Mine Inspectors ordered the abandonment of a camp which in his opinion had been established in a slide path. The operator objected to this directive, drawing attention to the growth of a clump of trees above the camp and in the believed avalanche path. Forthunately, the Inspector insisted on the change of location because a few years later, the slide re-established itself destroying an explosives magazine at the old campsite.

Of interest also is an incident concerning a mid-summer avalanche. Late in June one year an Inspector on visiting an exploration tent camp on the side of a mountain at the south end of Lake Atlin requested that the camp be relocated. This camp had been erected in a brush free slide draw and the Inspector requested it to be moved out of the draw and onto the hillside. The request met with some opposition inasmuch as it was mid-summer however all but the supply tent had been moved out of the draw when a slide swept down it destroying the tent. It is believed warm weather had melted the snow higher up on the mountain and had triggered the slide.

It can be readily seen that the training of personnel in varicus aspects of search, rescue and property protection is a valuable factor in pre-crisis preparation but the value of the examination of past crises remains to be demonstrated.

PAST CRISES EXAMINATION

An analytical examination of the records of past crises can reveal how past actions or the failure to exercise such actions can effect favourably or adversely the outcome of a crisis management situation. Thus the incorporation in some manner or the other of this information in the preparation of an organizational plan to be exercised in the event of a management crisis prepares a manager to be able to operate at his best capacity even though subjected to the stress of the occasion.

Before such a plan is made for any mining operation a review should be made to assess its existing hazard potentials and with this knowledge endeavor to profit from the experiences of others where management crises occurred in respect to a similar hazard. This does not mean that the individual making this assessment should be prescient but obvious hazard potentials should direct them in making use of the experiences of others to assist them in their planning.

To assist in categorizing the general hazard potentials which might be present in a mine I reviewed several years of the Annual Reports of the Minister of Mines and would submit that most of the occurrences of crisis management action would be situations which could be classified under one of the headings listed, in general scope of each of which I have defined.

Avalanches -- This includes the occurrence of these phenomena at the mine site, the mine plant including the mill, the mine camp or townsite, the service roads about the property, and the main access roads. It also includes snowslides off the roofs of plant buildings which in the past have been the cause of fatalities.

Cave-in -- This includes instances where underground workings have caved through to the surface, or uncontrolled collapse of underground areas, or incidents involving airblasts. Bumps and outbursts could be listed here or if preferred, listed independently.

Explosions and/or fires This includes any such event, surface or underground where noxious and irrespirable gases have been produced. Included in this group are circumstances where irrespirable atmospherees are present but not necessarily having been generated by a fire or explosion but are circumstances where self-contained breathing equipment would be essential for rehabilitation.

Floods -- This includes any circumstance, surface or under-

ground, involving the flow of large volumes of water or water saturated material. It includes the sudden release of appreciable volumes of entrapped water, and also the breaching of tailings dams.

Hoisting and Haulage Incidents — This includes those incidents where lives have been lost or endangered by damage, structural failure, or uncontrolled operation of such equipment.

Slides of Rock Clay, etc. — This includes shear failure in previously stable rock or overburden, waste dumps (surface or submarine), construction fill sites.

With reference to this foregoing classification it is possible that at any individual property one or more of the listed hazards could be dismissed as inapplicable but those remaining should be scrutinized to determine if the hazard could be removed or avoided or controlled in any manner so that should it become a reality, its effect might be mitigated. If this is neither possible or practical then one should presume that if the hazard transpired into an incident of reality to one operator it is possible that it could do so to another, therefore, what can be learned of the first's experience which would better prepare the other. To demonstrate how this can be done let us return to the accounts of the Pacific (Eastern) Gold Mine methane explosion and the Granduc avalanche which I hope it is realized only brief accounts were presented and a lot of detail omitted for brevity in this presentation. However, I chose these occurrences to assist in demonstrating the extraction of guidance and experience information from the accounts given. It is suggested that each of these incidents be examined and a list made of commendable practises taken both before and subsequent to the event that facilitated and expedited search and recovery operations. Then being aware of current technical knowledge, training and equipment, include whatever action could now be taken to improve search and recovery efforts. In other words, examine the incident in retrospect in light of current resources available. Having made a list as suggested the operator with a similar incipient hazard should examine his establishment to insure that the available resources and practises are adequate to cope with such an emergency should it occur. In addition, any noteworthy actions in expediting performance should be retained for future guidance. In the events chosen it might be said that had ventilation been maintained, the methane explosion would not have occurred and if qualified advice had been sought before the Leduc Camp was built, it would not have been located where it was. However, both incidents did occur, hence assess whatever action, prior or subsequent to the event, that is worthy of emulation.

In respect to the two events discussed, I have listed in tabular form the actions taken or in retrospect recommended under the headings "Pre-Crisis Preparation" and "Action Subsequent to the Event". This distinction was made so that any successful immediate action after the occurrence of the event would be highlighted for future application. The examination of the full reports of these incidents would, I am sure, add other items to this list which is merely a sample of my suggestion.

PACIFIC (EASTERN) GOLD MINE

PRE-CRISIS PREPARATION	ACTION SUBSEQUENT TO THE EVENT
1. Maintain ventilation. 2. Provide mine rescue equipment. 3. Train personnel in use of mine rescue equipment. 4. Train personnel in mine rescue procedures. 5. Keep self rescue training up to date with refresher classes. 6. Provide supervisor refresher training. 7. Have emergency organization plan prepared.	1. Re-establish ventilation as soon as possible. 2. Establish local communication as soon as possible. 3. Early contact made with Chief Inspector to obtain additional assistance.

GRANDUC AVALANCHE

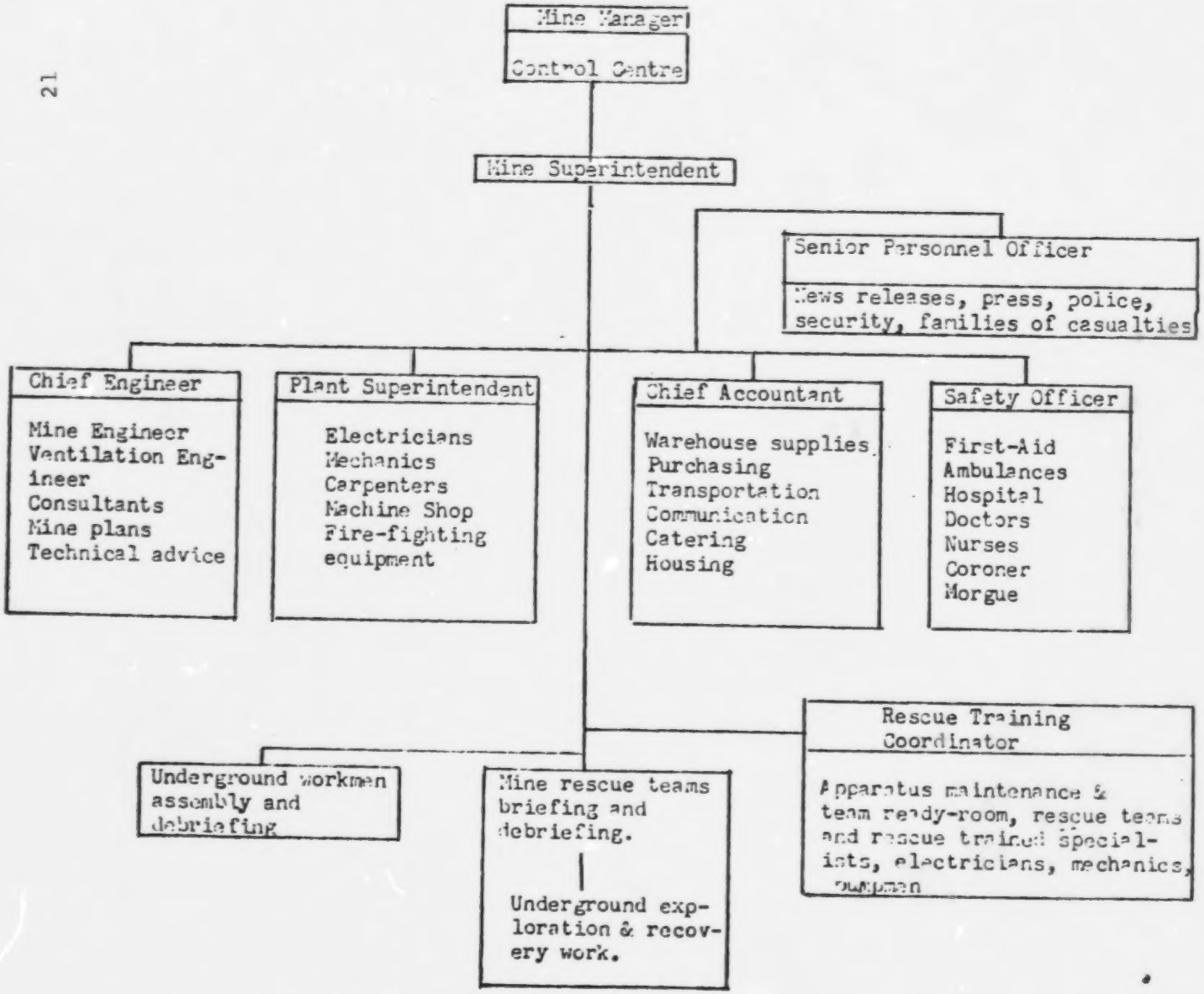
PRE-CRISIS PREPARATION	ACTION SUBSEQUENT TO THE EVENT
1. Obtain avalanche expert advice before any installation made. 2. Have some personnel trained in avalanche control, search, and rescue procedures. 3. Provide necessary equipment for item 2 above. 4. Equip personnel as necessary with radio transceivers. 5. Have emergency organization plan prepared.	1. Auxiliary power available. 2. Communications established promptly insured early assistance. 3. Early contact with Inspector made extra assistance available. 4. Medical services available immediately. 5. Transportation arrangements made for prompt removal of injured. 6. Search and rescue commenced quickly. 7. Early employee tally check made. 8. Identify most likely search areas and if required have area plans available. 9. Insure adequate accommodation and food available for survivors and rescue crews. 10. Rescue procedure accelerated by improvisation.

CRISIS ORGANIZATIONAL PLAN

No two incidents involving crisis management control are identical in all respects and commendable actions taken in one case may not necessarily be of value in the other. However, in all instances the services of people are essential and include not only workers but also those having particular skills or training. A list of these would include mechanics, electricians, engineers, doctors, etc., and a review of the summaries made of Past Crisis Examinations would indicate all these individuals and others. As it would be impractical if not impossible for a mine manager to individually contact each person when their services are required, he should arrange that these and other responsibilities are delegated to his staff and are assigned to them as best suited to the normal functions of their office. Each staff member so appointed should be made fully aware of the personnel and responsibilities assigned to them and how these are expected to be coordinated with those assigned to any other staff member.

Essentially the organizational layout should be such that the manager remains in overall control and, depending on the site of the incident inducing the crisis, the mine, mill, plant, or surface superintendent will be in direct charge of the operations coping with the situation and assisted by supplies and services made available by the other appointed staff members. For brevity this organizational layout should be represented in chart form with the names and phone numbers (office and home) of all appointed staff members together with those of their alternative appointees listed on the chart. This chart, when issued, should be given widest circulation and posted so that the information contained is immediately available to anyone requiring it. It should be continuously updated with due consideration made to absences of the appointed staff personnel because of holidays, etc.

Mention was made earlier in this paper of such a chart appearing in the Instructor's Survival Rescue Manual and which I have here taken the liberty to reproduce with some modifications. This chart is specific to an underground mine where mine rescue teams would be required.


Mine Manager
Control Centre
Mine Superintendent
Senior Personnel Officer
News releases, press, police, security, families of casualties
Chief Engineer
Mine Engineer
Ventilation Engineer
Consultants
Mine plans
Technical advice
Plant Superintendent
Electricians
Mechanics
Carpenters
Machine Shop
Fire-fighting equipment
Chief Accountant
Warehouse supplies
Purchasing
Transportation
Communication
Catering
Housing
Safety Officer
First-Aid
Ambulances
Hospital
Doctors
Nurses
Coroner
Morgue
Rescue Training Coordinator
Apparatus maintenance & team ready-room, rescue teams and rescue trained specialists, electricians, mechanics, pumpmen
Underground workmen assembly and debriefing
Mine rescue teams briefing and debriefing.
Underground exploration & recovery work.

In conclusion, having since 1948 been associated with the expansion of underground mine rescue training in metal mines and with the creation of surface mine rescue and survival rescue training, all of which are based on using the past unfortunate experiences of others during some critical event to provide a means of offering protection to people during future hazard crises; and having several times been involved in the amending and revising of the Coal Mines Regulation and Metalliferous Mines Regulation Acts in British Columbia, and about which I can certify most amendments made in the General Rules in these Acts since 1948 originated also as a result of someone's misfortune; and having every reason to believe those in existence prior to that date were as a result of similar circumstances, I am firmly convinced the analyses of past crisis management events can provide a wealth of information and experience to lessen the frequency of such occurrences and to provide organized direction in meeting and successfully handling future incidents of crisis management.

NEW SOUTH WALES MINES RESCUE SERVICE

and a

CASE STUDY ON THE APPIN COLLIERY DISASTER OF 24th JULY, 1979

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by

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NEW SOUTH WALES MINES RESCUE SERVICE AND A CASE STUDY ON THE APPIN COLLIERY DISASTER OF 24TH JULY, 1979

The State of New South Wales currently produces some sixty (60) million tonnes of black coal per annum from seventy (70) underground mines and twelve (12) open cut mines with further open cut and underground operations being developed.

Following the Bellbird Colliery disaster of the 1st September, 1923, the Mines Rescue Act came into force on the 31st December, 1925.

The Act provided for the establishment of a central rescue station in each of the four principle coal mining districts of the State, the manning of each station by a permanent corp under the direction of a superindentdent, and the training of volunteers. (Appendix 3)

The sites selected were then central within the four mining districts namely:

(i) Newcastle - at Cockle Creek
(ii) South Maitland - at Abermain
(iii) Southern - at Bellambi
(iv) Western - at Lithgow

Each station was to be under the direction of a Committee comprising four persons representative of the Colliery Proprietors within the district plus the District Workmans Safety representative (District Check Inspector). The proprietors representatives are elected by ballot at three yearly intervals.

Funding and administration was the task of the Committee, who were empowered to strike a yearly levy on the coal mines in the district to operate and maintain the station and equipment.

A station was built and equipped in each of the four district sites by the end of 1928. Station sites have, to date, remained unchanged, however, this will alter in the near future to meet the changing location of mining centres. The breathing apparatus then used was the Mark IV Proto. Presently three stations are equipped with Draeger BG 174 breathing apparatus and the other station with Aerolox and Draeger LOX 120 Liquid oxygen apparatus.

The Southern Mines Rescue Station uses the mutual assistance scheme in that sufficient apparatus is maintained at each colliery so that a team from the affected colliery, with backup from the nearest colliery can commence a rescue operation prior to the arrival of the rescue station equipment and personnel, (Appendix 1)

The other stations maintain sub stations in selected areas with sufficient equipment to allow local teams to commence an operation in their area pending the arrival of the rescue station equipment and personnel.

In recent times, the problems of funding each of the stations became inequitable, particularly the western district which is the smallest and was suffering a decline.

Legislation then provided for the formation of a Mines Rescue Board, a Central Board whose purpose is to determine the yearly levy on all Colliery Proprietors in the State and to recommend the disbursement of funds to the Rescue Stations. The rescue stations still operate under the control of district committees.

The Mines Rescue Board consists of:

(a) The Chief Inspector of Coal Mines as Chairman;

(b) A person nominated by the Minister, representing the Electricity Commission;

(c) A person nominated by the Australian Coal and Shale Employees Federation (Miners Federation);

(d) A person nominated by the Colliery Staff Association;

(e) Two persons nominated by the New South Wales Combined Colliery Proprietors Association; and

(f) A person nominated jointly by BHP Pty Co Ltd and Australian Iron & Steel Ltd.

A member of a district committee cannot be a Board member.

The function of the Board has provided some unification in what was otherwise a number of independent systems.

Recently the Board has had constructed a new station at Lithgow (Western District) and work has commenced on the construction of a station and housing at Singleton with a view of transferring the Abermain Rescue Station activities (South Maitland District) to that location.

Planning is presently in progress for a station near Appin which will ultimately replace the present station at Bellambi (Southern District).

The present disposition of personnel, volunteer trained persons and equipment is as follows:

STATION	Volunteer Trained Persons	Rescue Station Personnel	BG174	Liquid Oxygen SCBA
			including sub-station and/or Collieries	
South Maitland	89	9	48	-
Newcastle	245	9	-	62
Southern	497	12	163	-
Western	63	9	58	-

In addition, there are 76 (BG58/1600) Compressed Air Units at the Newcastle District Collieries.

CASE STUDY - APPIN COLLIERY EXPLOSION - 24TH JULY, 1979

A summary of the occurrence and investigation into the explosion was presented by Mr. R.J. Kininmonth, Senior Inspector of Collieries in a paper to the Australian Institute of Mining and Metallurgy's Symposium on Ignitions, Explosions and Fires in Coal Mines Symposium, May, 1981.

With his kind permission, the majority of that paper has been reproduced as it adequately summarises the circumstances of the explosion and the recovery operations.

His paper also deals with the investigation and the results of both a Judicial Inquiry and a Coronial Inquiry, both of which were conducted as a result of the relevant requirements of the Coal Mines Regulation Act and the Coroners Act.

This section has been included as a matter of interest to the participants of this Symposium. It is not my intention to present the details of the investigation, however, I would be pleased to deal with any inquiries that may be directed as a result of this presentation or in private discussion.

I have added a summary review of the problems which were encountered in the Management of the Operation and comments on problems of responsibility for the conduct of such operations.

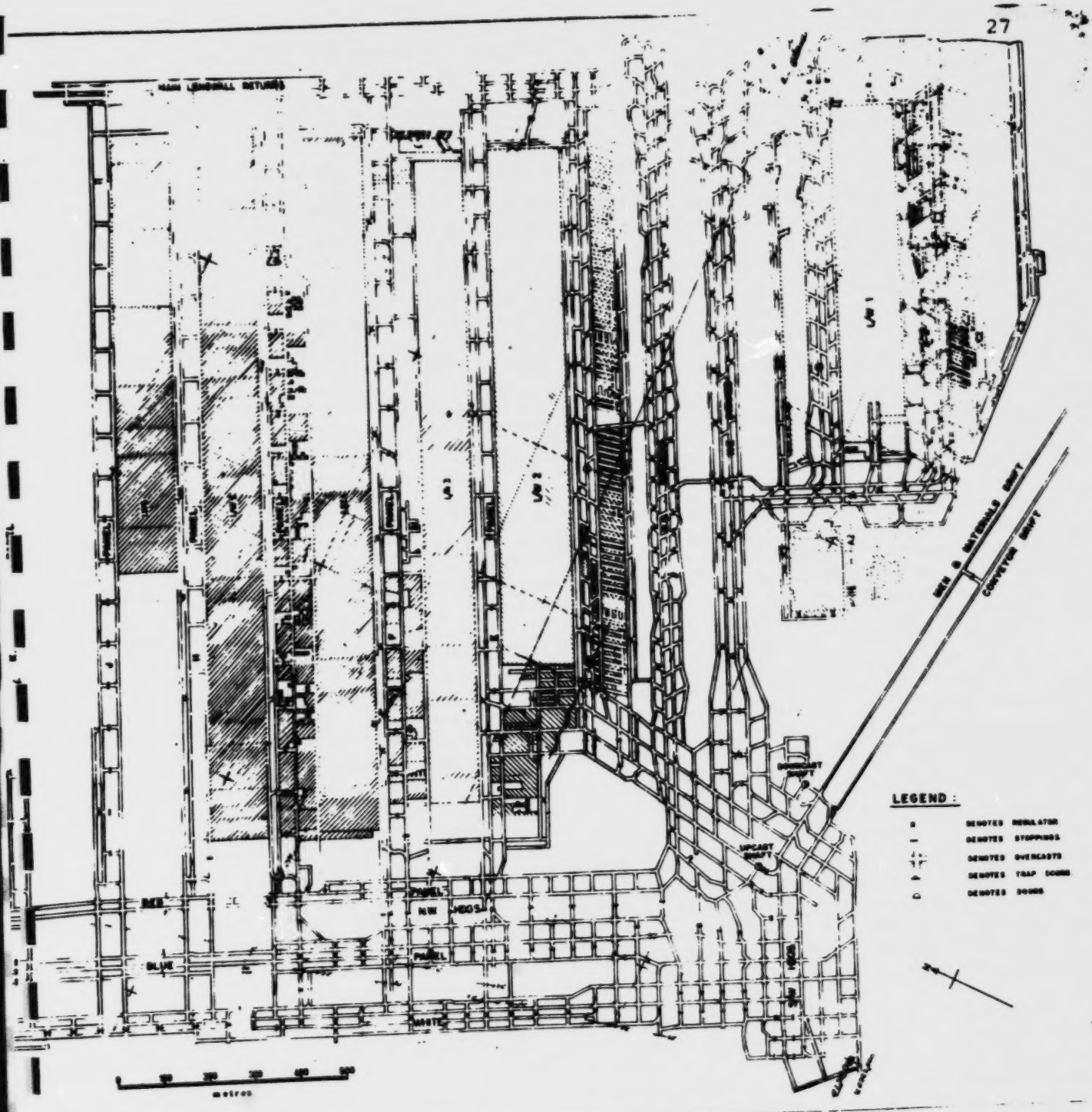


FIGURE 1

APPIN COLLIERY - 24th JULY, 1979

SUMMARY OF INVESTIGATIONS INTO APPIN COLLIERY EXPLOSION

ABSTRACT

At 11:00 p.m. on Tuesday, 24th July, 1979, an explosion of methane in a three heading development panel at Appin Colliery resulted in the deaths of fourteen men.

The explosion followed after or was associated with a change-over of the ventilation to achieve a central intake between two returns.

INTRODUCTION

Appin Colliery is situated behind the Illawarra escarpment approximately 36 km from Wollongong and works the Bulli Seam, approximately 3 m in thickness at a depth of 510 to 570 m. The layout of the colliery is shown in Fig. 1.

Colliery development by continuous miners began in 1962 and high methane emission from solid coal was a feature of that development. Pillar extraction and longwall goaves also produce large quantities of methane and the return shaft carried approximately 225.0 c.m.s. of air at 1.0% methane.

Ryan and Beath (1970) described the problem of gas emission during development and the use of return roadways on each side to protect the track and conveyor roads from gas emission from the virgin coal. Fisher (1976) also discussed the ventilation constraints on development and inter alia stated "Development panels needed their intake airways to be shielded by peripheral return airways to pick up methane given off from solid coal".

The layout of development panels, for both longwall retreating and pillar extraction, by the Wongawilli system have been described by Fisher (1976). The early longwalls were not high producing units and it was found that the development headings could be driven at relatively slow rates of advance. This slow advance and an emphasis on high quantities of ventilation allowed the use of two heading panels for longwall development provided the heading on the virgin side was used as the return.

As one block was mined, another was formed by the next two heading development. It was then necessary only to drive a single heading on the maingate side. That heading could be driven largely in destressed conditions with a minimum number of cut through connections. The roadway was thus newly formed and supported when put into use as the next longwall maingate.

By mid 1979 five longwall blocks had been extracted and a sixth was partly finished. Blocking out for longwall seven was in progress in "K" panel by mining to the North East from the main White Panel development headings.

VENTILATION

As the longwalls became more successful speed and development became more important and despite continuing improvements in ventilation control it became increasingly difficult to meet the standards of methane control without periodically stopping production.

Distribution of air to the faces in development panels is normally by auxiliary exhaust ventilation. Despite the supply of up to 28 c.m.s. of air at the last cut through, it was not always possible, particularly in H and J panels, to maintain intake methane levels below one quarter of one per cent at a distance of 100 m from the first working face.

Dilution of methane in development panels is largely dependent on providing large quantities of air to the face areas and in attempting to improve face conditions the method of auxiliary fan ventilation was progressively altered. Early development panels used axial flow fans with an open circuit capacity of 8.5 c.m.s. attached to 600 mm ducting but these were changed for centrifugal fans which had an open circuit capacity of 9.4 c.m.s. The better characteristic curve of the centrifugal fans ensured larger air quantities in long lengths of ducting. At a later stage the vent ducting was increased to 760 mm diameter and eventually approval was given for two fans to be used in parallel through the single ducting.

Despite these improvements it became obvious that the methane percentage, which reached up to 0.6% at the last cut through, prevented adequate control at the face and resulted in production being stopped on numerous occasions.

DEVELOPMENT IN 'K' PANEL

The use of returns on both sides of a panel during early development at the colliery has already been mentioned. It was found, for later development, that some reduction in intake methane emission occurred if the panel was adjacent to an already driven panel. Development of two heading panels with headings at 40 m centres and cut throughs at 90 m centres was therefore possible provided the rate of advance was slow there was an adjacent earlier development, and the return heading was situated on the virgin side so that the bulk of the panel gas was released into the air stream after it had left the face area.

As the longwall operations at the colliery became more successful, faster rates of development drivage were required. Experience in H and J Panels indicated that such faster development in two heading panels resulted in high intake methane readings and in difficulties in methane control at the face. Early experience with methane drainage had not been successful (McCoy, 1976). Some preliminary attempts at drainage in seam in H and J Panel had been tried but the technique had not been developed to the extent where it could be seen as a production tool.

The speedy development of 'K' Panel became essential as a means of blocking out a new face to replace longwall six which was rapidly retreating. In the initial development two headings approximately 2.4 m high and 5 m wide were driven. Despite the need for rapid advance rates it was decided to alter the system of work and to change to a three heading development with returns on each side of a single intake. The disadvantages of this scheme were the relatively slower rate of development with returns on each side of a single intake. The disadvantages of this scheme were the relatively slower rate of development and the fact that the second return, which would eventually become the next maingate heading, would be formed earlier than usual and be more liable to stress deterioration. The two heading development was stopped in mid June when the panel had advanced to No. 4 cut through and the third heading was driven to catch up. It was immediately used as the single return and the other two were intake.

It has been decided that some lost time could be made up if, after the changeover, two continuous miners were worked on production at the same time. A second miner had been sent into the panel for this purpose. Discussions were held with the District Inspector regarding use of a fan in each return and additional air was provided to ensure an adequate quantity for the two fans.

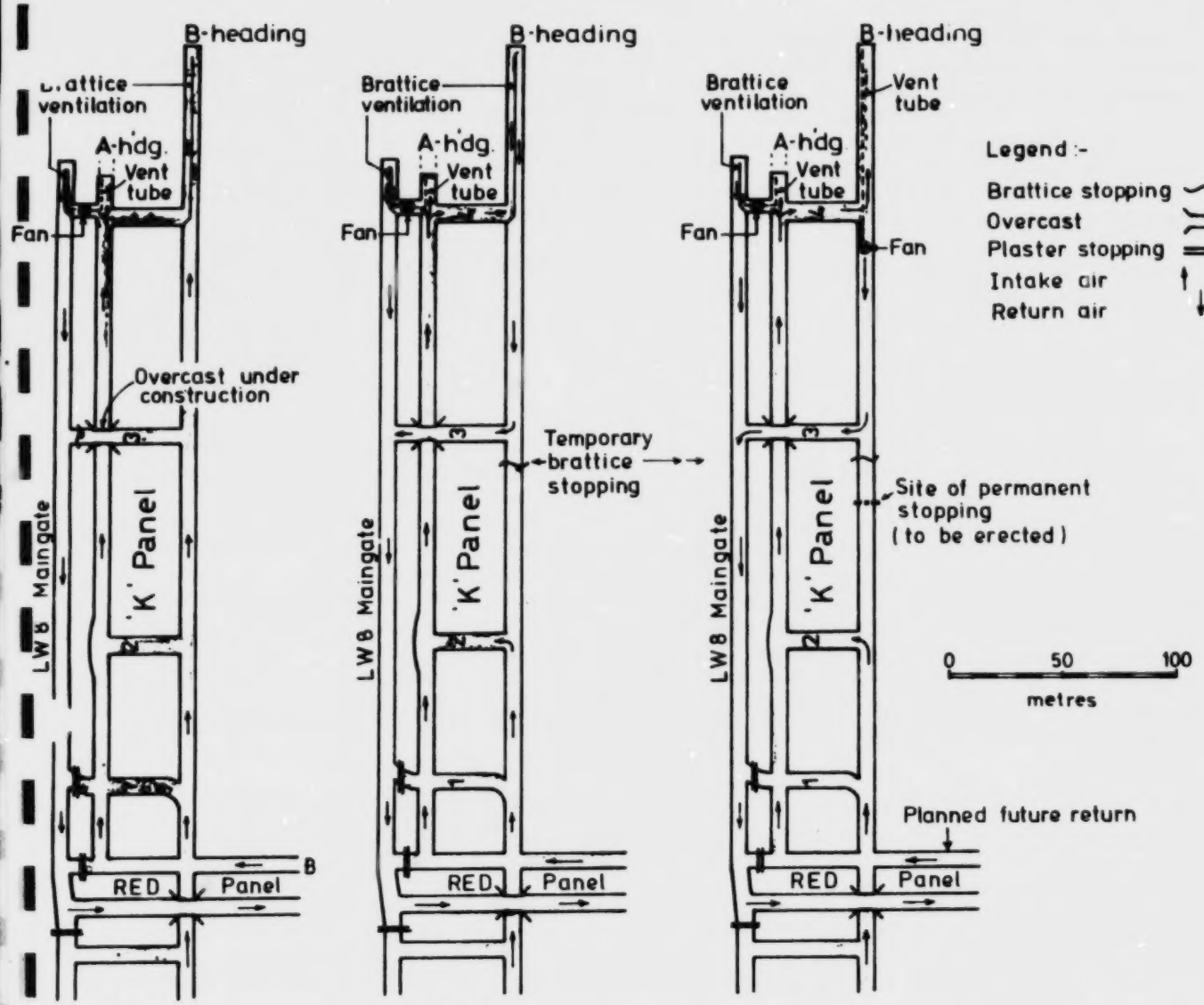
The changeover could not be made until an overcast was completed at No. 3 cut through to connect B heading and L.8 maingate. From that point outbye to Red Panel L.8 maingate was to be a single return. Initially A heading of Red panel was to be the single continuation of that return but plans were in hand for building another overcast to allow use of B heading of Red panel as a duplicate return.

PLANNED VENTILATION CHANGEOVER

On the day and afternoon shifts on 24th July, 1979, final preparations were being made and instructions were given to an afternoon shift deputy to make the ventilation changeover if and when the work was completed.

The conditions in the panel prior to the changeover and the intended effect of the changeover are shown in Fig. 2. Stage 1 shows the panel layout on the morning of Tuesday, 24th July, 1979, and A and B headings as intakes and L.8 maingate as the return. The overcast at the intersection of No. 3 cut through and A heading was being built. L.8 maingate stub inbye of No. 4 cut through was brattice ventilated.

A heading stub was ventilated by an exhaust fan situated in the cut through and B heading which had been driven forward 70 m as an intake stub was ventilated by brattice. Stage 2 shows the intended post changeover ventilation. This was to be achieved by erection of a temporary brattice stopping in B heading outbye No. 3 cut through. A fan with associated vent tubes had been placed in B heading and Stage 3 shows the effect of replacing the B stub brattice by that fan, a step which was necessary before both miners could be operated.



STAGE - 1.
Before ventilation change

STAGE - 2.
Planned ventilation system - after ventilation change, but prior to starting 'B' heading fan.

STAGE - 3.
Planned ventilation system with both fans running.

FIGURE 2

APPIN COLLIERY - CHANGEOVER PLAN

When the overcast was completed near the end of the afternoon shift, the deputy arranged for the brattice stopping to be erected in B heading. The changeover should then have been completed by the removal of the brattice in No. 3 cut through but the deputy became aware of a drift of air from the overcast across No. 3 cut through and inbye along B heading and he did not proceed. Instead as it was approximately 7.30 p.m., and the end of his shift, he left and reported to the incoming deputy who had arrived in the panel with his evening shift crew.

The extent of work carried out by the evening shift and its effect on ventilation could not be established because an explosion at 11:00 p.m. killed all 14 men in the panel.

RESCUE OPERATIONS

At the time of the explosion there were 56 men underground in the colliery. The 14 men in K panel represented a normal development crew of six men and a deputy plus an additional crew whose job it was to complete the work necessary for operation of the second continuous miner and at some stage in the shift to commence mining. There was also present an assistant undermanager who entered the panel shortly before the explosion, having spent most of the earlier part of the shift in the control cabin near the bottom of the men and material drift. A shift electrical engineer who had travelled in by diesel man car and was fitting a junction box in D heading of White panel approximately 26 m outbye of its intersection with B heading of K panel suffered second degree burns to the fingers of both hands and first degree burns to his head and face.

The deputy in charge of a crew of men in White panel was sitting in the White panel crib room which is situated in the next cut through about 90 m outbye of the intersection of B heading of K panel and D heading of White panel. He was knocked to the floor and received minor singeing of the hair and eyebrows. The White panel crew were undoubtedly protected from the direct effects of the explosion by a substantial fall which blocked L.8 maingate 80 m from D heading of White panel. The six men in the White panel crew made their way to the crib room.

A crew of ten men, including a deputy were working on Longwall 6, some 950 m from White Panel. They reached safety, under the guidance and control of the deputy, wearing self rescuers despite having to travel by feel for much of the way because of the dust laden air.

At 11.46 p.m., the Southern Mines Rescue Station was informed of the event. The Mutual Assistance Scheme was put into operation and the Superintendent and Assistant Superintendent left for Appin at 11.55 p.m., followed by three emergency vehicles which had all arrived at Appin Colliery by 12.29 a.m.

APPIN COLLIERY

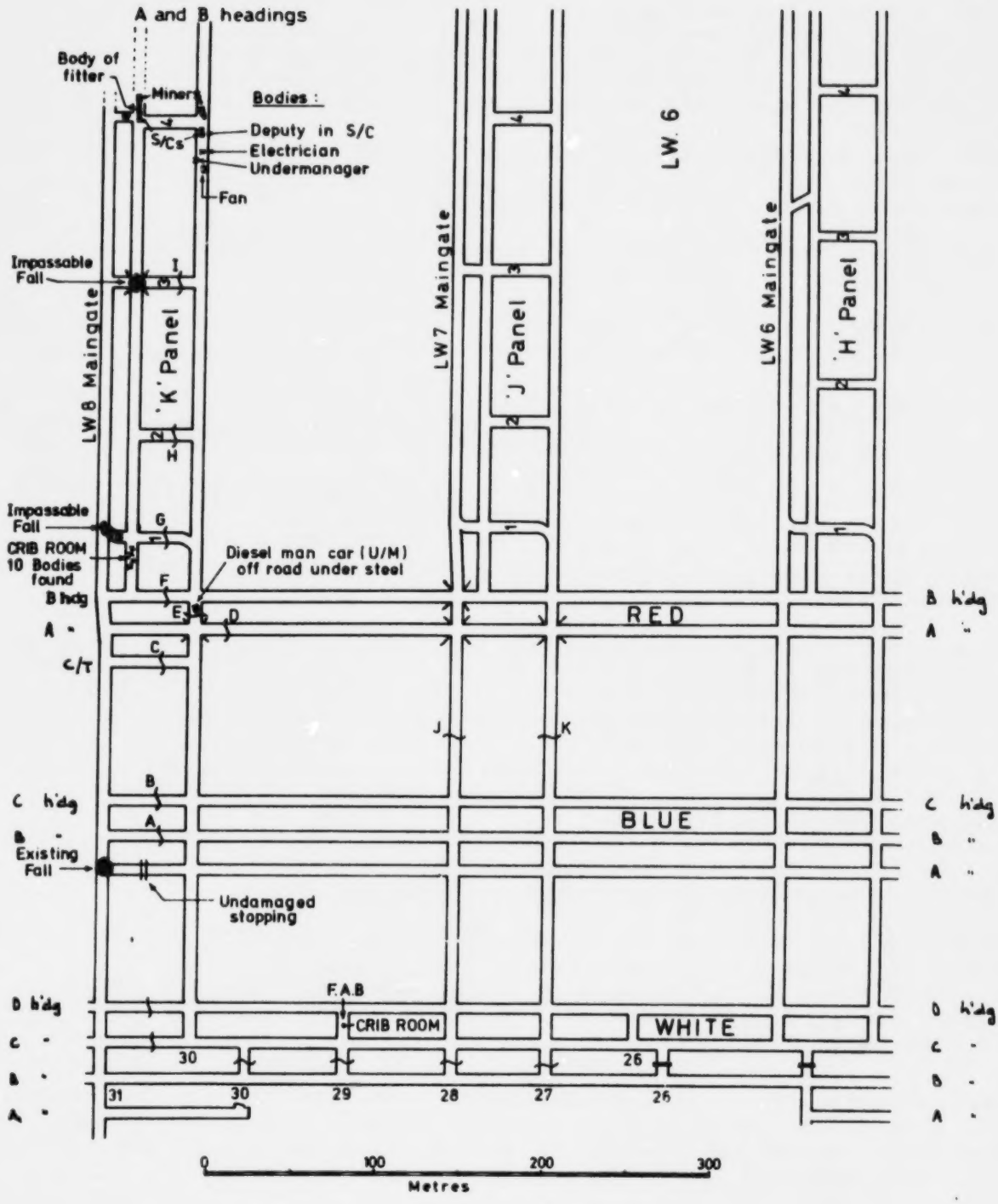


FIGURE 3

RESCUE OPERATIONS PLAN

The Superintendent, Assistant Superintendent, four permanent corpsmen, the Colliery Undermanager, an Assistant Undermanager and three Colliery Rescue Men (2 Rescue Teams) left to go underground at 12.35 a.m. They proceeded by drift transport then diesel man car, to White panel crib room which was just outbye the entrance to 'K' panel. This was established as the Fresh Air Base (F.A.B.) for the following reasons:-

(a) Rail Transport was available to the pit bottom.

(b) There was a telephone to the surface.

(c) Intake ventilation, though sluggish, was moving and there was no CO or CH_4 in the air when tested.

(d) It was out of the direct line of 'K' panel headings should any further ignition occur.

The F.A.B. is shown on the Rescue Operations Plan (Fig. 3), adapted from Strang (1979), which shows the features mentioned in the following text which summarises a report by Strang (1979).

A team under the captaincy of the Colliery Undermanager left the F.A.B. at 1.00 a.m. and returned at 1.50 a.m. They had discovered the bodies of ten men in the 'K' panel crib room, some 290 m from the face of a heading, and found progress further inbye impossible because of poor visibility.

Brattice stoppings were erected to replace the brick stoppings which had been blown out in 27, 28, 29 and 30 cut throughs in White panel and additional stoppings 30c, 30d, A, B and C in K panel erected to force air into K panel. Arrangements were made to erect stoppings D, E, F and G to provide a return along B heading of Red panel.

The disruption of outbye stoppings had reduced the quantity of air available and the large number of brattice stoppings resulted in leakage so that progress into the panel was slow. By 10.15 a.m., a team was able to travel into the face area and discovered two bodies in B heading and one in A heading.

Stopping H was built in No. 2 cut through of K panel but it was then found necessary to erect stoppings J and K in J panel to force more air into K panel before stopping I could be built. A bag sample taken inbye of No. 3 cut through at 5.45 p.m., showed 0.6% CO, 12.2% O_2, 1.8% CO_2 and over 20% CH_4.

When stopping I had been completed and some time allowed for removal of a gas a team proceeded inbye in relatively clear visibility and at 8.30 p.m., discovered the body of the last missing man behind the prop line in B heading.

The rescue operation involved 170 volunteers and lasted 41 hours from 11.45 p.m., Tuesday, to 5.00 p.m., Thursday, although the last 12 hours were mainly occupied in routine repair work.

APPIN COLLIERY

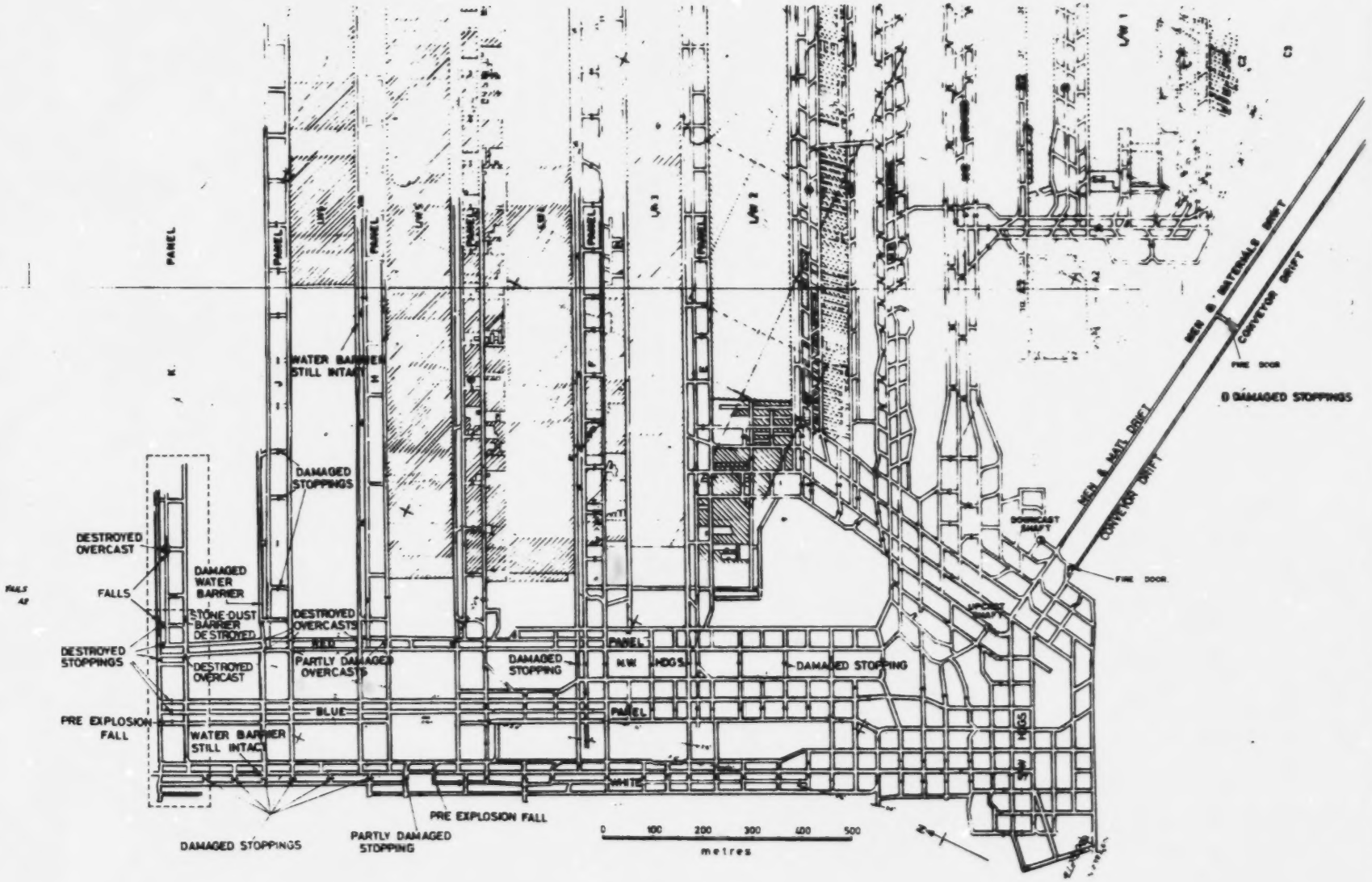


FIGURE 4

EXTENT OF STRUCTURAL DAMAGE

DAMAGE ASSESSMENT

The major structural damage both outbye and in 'K' panel is shown in Fig. 4.

The items of special interest were:-

(a) The water barrier in Longwall 7 maingate of J panel was damaged. Neither the barrier in White panel conveyor road nor the barrier in Longwall 6 maingate in H panel were damaged.

(b) The overcast at the intersection of B heading of K panel and B heading of Red panel was completly destroyed as was the one at the intersection of No. 3 cut through and A heading where a major fall had occurred.

(c) The stone dust barrier between No. 1 and No. 2 cut throughs in B heading was destroyed.

(d) The fan ducting in B stub was shredded and the fan blown down B heading a distance of approximately 30 m.

(e) Steel purlins bolted to the roof in B stub were distorted.

(f) Considerable damage had been done to L. 8 maingate where the wooden props had been blown out from under the steel rail supports.

The damaged equipment inside K panel which was considered relevant to assessing the cause of the explosion consisted of:-

(a) The B heading fan starter which was found in a non flameproof condition.

(b) A damaged cable off the shuttle car in B heading.

(c) A damaged cable off the B heading fan.

(d) A damaged cable laid out into B heading stub and attached to the continuous miner at the intersection of No. 4 cut through and B heading.

(e) A damaged methane monitor which had been broken off the B heading continuous miner.

(f) A damaged methanometer which had been in the possession of the Assistant Undermanager.

(g) Damaged flame safety lamps.

(h) A damaged multimeter found in B heading.

FORMAL INVESTIGATION

On 25th July, 1979, the Minister for Mineral Resources and Development in pursuance of the powers conferred by Section 31 of the Coal Mines Regulation Act, 1912, directed that an investigation be held by the Court of Coal Mines Regulation established under the Act. The resulting inquiry was held by His Honour Judge A.J. Goran and a report delivered on 9th May, 1980.

Subsequently a Coronial Inquiry under the Coroners Act, 1980, was held before Stipendiary Magistrate J. Hiatt, and a report delivered on 19th December, 1980.

During the days after the explosion, Inspectors from the Wollongong Office carried out an assessment of the situation and following an underground inspection by Judge Goran and other interested parties, arrangements were made for recovery and testing of items relevant to the Inquiry. Inspectors, along with technical staff from the Department's Chemical Laboratory at Lidcombe and the Londonderry Test Centre, made an on the spot evaluation of the equipment of special interest to the investigation. The Chemical Laboratory personnel collected samples for testing. Other items were taken to the surface for distribution to Londonderry and Lidcombe.

Colliery staff under the guidance of an Inspector, spent many days of careful sifting and note taking which became the basis for compilation of a comprehensive set of plans which were subsequently used at the Inquiries.

Apart from a number of interim reports which were provided at the start of the Judicial Inquiry on 24th September, 1979, a total of 24 detailed reports were prepared for presentation at that Inquiry.

SUMMARY OF RELEVANT REPORTS

SITE OF IGNITION

Scientific evaluation of the post explosion evidence was carried out and Ellis (1979) stated:

"It is significant that the flame was of low velocity except at its point of origin (B heading inbye No. 4 cut through) and in longwall 8 maingate outbye No. 3 cut through. This fact points to the presence of significant amounts of inert material, which could only be stonedust.

I am therefore of the opinion that stonedust played a major role in limiting the flame speed, and in eventually arresting the flame."

APPIN COLLIERY

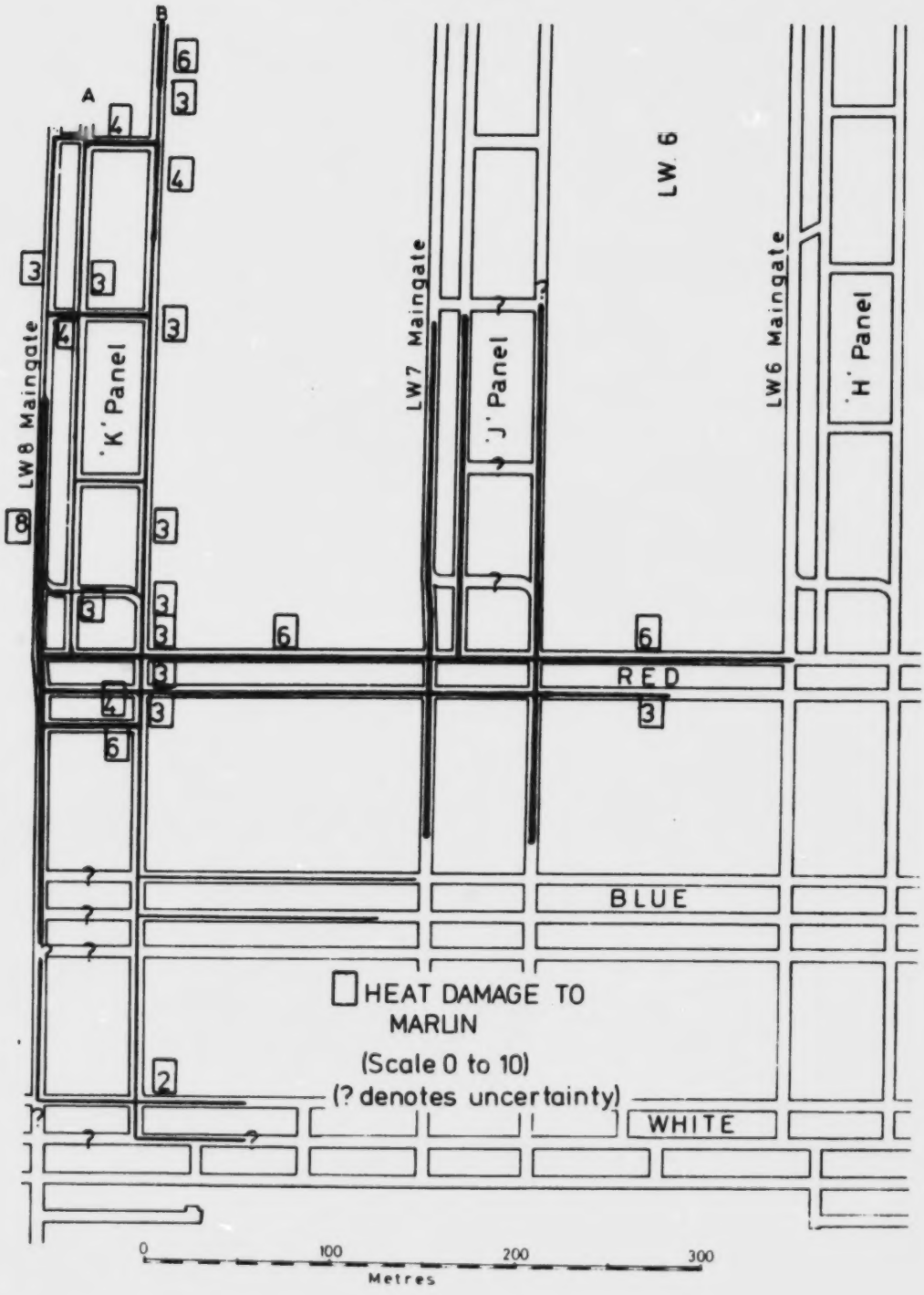


FIGURE 5

EXTENT OF FLAME TRAVEL

FLAME TRAVEL

Fig. 5 adapted from Ellis (1979) shows the extent of probable flame travel determined after examination of heat damage to marlin and after calculating the volatile content of coal matter in roadways. In discussing the flame travel Ellis (1979) commented "The extent of flame suggests the involvement of coal dust" and he went on to say:-

"The degree of damage produced in B heading near the face and back past No. 4 cut through suggests a violent explosion resulting from ignition of a body of gas near its inbye end.

If this conclusion is correct, it limits the possible locations of ignition of the methane to either the face, or a point from which flame could travel to the face. The vent tubes provided one path by which flame could travel to the face and there ignite a body of gas at its inbye end. I am uncertain that a roof layer of methane could behave in this way. It would seem that flame travelling via a roof layer of methane must ignite a body of gas at its outbye end. It would then produce an explosion which was incapable of initiating a coal dust explosion."

FAN STARTER

The auxiliary fan in B heading has been described as a 445CP490CY centrifugal with an open circuit capacity of approximately 9.4 c.m.s. manufactured by D. Richardson & Son and driven by a 50 H.P., 415 Volt 3 phase squirrel cage induction motor. The associated starter was attached to the fan as a unit and consisted of a flameproof control box containing a 190 amp. three phase contactor with associated control and protection circuits. The fan assembly was found in B heading thrown 30 m outbye from where it had been placed. Examination showed that the door was fastened by only one stud which was entered only to a depth of two threads. The remaining 23 studs were not immediately recovered but most were found during subsequent searches.

Fisher (1979) has described the condition of the interior of the fan starter, including the presence of burning on rope samples, and a dust pattern showing signs of gas flow on a receptable end blanking plate. Attempts at Londonderry to reproduce these effects resulted in one success when a flammable mix was present in the starter but the result could not be reproduced again. It was not possible to produce the same effects when gas was ignited outside the box. Lloyd (1974), in discussing the investigations carried out at Londonderry, concluded:-

"The fan switch was by far the most probable source of ignition that initiated the explosion of gas at Appin Colliery for the following reasons:-

(1) The switch in its condition at the time of the explosion was not flameproof due to the excessively large gap between the flanges of the cover and main enclosure and the absence of all but one of the fixing studs. Operation of the contactor with the enclosure in this condition caused an external mixture to be ignited on each occasion that a flameproof test was performed at Londonderry.

(2) Charring of flammable material inside the enclosure indicated that an internal explosion had occurred. Additionally the fineness of the dust found inside led to the same conclusion.

(3) The dust pattern in the blanking plate indicated that this explosion had been ignited from inside the starter.

(4) The electrical supply was on to the fan as indicated by arching on the fan cable where it was damaged as a result of post explosions disturbance.

The two factors in No. (2) indicate that an explosion inside the enclosure occurred i.e., there had been an explosive mixture inside the starter. Factor No. (3) is evidence that the explosion was initiated from inside the box."

METHANOMETER

An Auer methanometer Model M402 normally carried by the assistant undermanager was found in a damaged condition approximately 5 m inbye of the final position of the fan. Initial inspection indicated the possibility of it being the cause of the explosion but extensive testing in flammable gas mixtures showed that it was not capable of initiating an explosion.

FLAME SAFETY LAMPS

Following the explosion two relighter type Protector Safety Lamps model CR 6S (A) were found in B heading. Lamp C55 was found alongside the body of the deputy inside a shuttle car at No. 4 cut through. The other similar lamp was found still attached to the body of the under-manager. A preliminary examination of these two lamps and two non-relighter lamps found elsewhere was made and this confirmed that lamp C55 was damaged and incomplete because the glass and a washer were missing.

A comprehensive investigation was initiated and was extended to include the general standard of maintenance and the control of spares for safety lamps. In a report detailing the investigations McKenzie-Wood (1980) stated:-

"Glasses with 'non-parallel' ends, found in colliery stock, fitted to a safety lamp in otherwise good condition, were found to ignite an external flammable atmosphere with internal ignition."

He went on to conclude:-

"There is no evidence to suggest that Lamp C55 ignited an external flammable methane atmosphere, however, this lamp contained defects that would have decreased its overall safety and, under certain circumstances, could have ignited an external flammable methane atmosphere.

These defects included:-

(a) Two pyrohor flints in the relighter mechanism, increasing the amount of pyrophor particles inside the lamp and causing a spark on key withdrawal.

(b) A severely corroded inner gauze, decreasing the ability of the gauzes to prevent the passage of flame.

(c) A worn glass plate, increasing the chances of lamp failure if assembled with a defective glass."

GAS MAKE

A gas survey was made two weeks after the explosion and Ellis (1979) records that methane was issuing in the 70 m long B stub at the rate of 1.5m 3/min.

VENTILATION

A ventilation reading taken in K panel on 23rd July indicated a total quantity of 26 c.m.s. It was expected that a slightly higher quantity would have been available on 24th July, but no information was available to indicate the likely distribution of that air after the changeover which was in progress on 24th July. Following reclamation of the panel an attempt was made to assess the effect of the proposed changeover on the split of air in the panel. Mould (1980) recorded the results of tests carried out in January/February, 1980.

The tests showed that with both auxiliary fans running the split of air was 45% along B heading and 55% along longwall 8 maingate and indicated that sufficient air was travelling in each direction to allow use of two fans.

One of the tests confirmed that minor leakage at the overcast could cause the reverse drift of airflow noticed by the deputy at the end of afternoon shift on 24th July, 1979.

MODEL TESTS

A series of model tests carried out in co-operation with the staff of the Southern Mines Rescue Station have been reported by Ellis (1980). The model consisted of a shortened 1/12 representation of B stub and illustrated the transfer of flame to the face via vent tubes and the higher strength of explosion when initiation occurs at the inbye end. It was possible to dislodge the model fan only when the gas was initiated inside the vent tubes.

Following the Appin Explosion, the Department of Mineral Resources built a 50 m long 2.7 m diameter circular testing gallery at the Londonderry Centre. Tests were carried out and Fisher (1980) has recorded the results. In one of the experiments the fan was moved 45 m by the violence of a 30 m length of 7.5% natural gas/air mixture which was connected to and fired from inside the starter box.

Both the above testing procedures used a uniformly mixed gas which does not simulate what would probably have been a layered condition in B stub.

INQUIRY FINDINGS

Judge Goran (1980) stated:-

"It is now obvious that I cannot accept as any form of probability the proposition that the deputy's safety lamp caused the first ignition. Nevertheless, a number of Counsel, representing varied interests, urged upon me that I should return what is often called in Coroner's Courts 'an open verdict'. They acknowledged the speculative nature of any finding 'in favour of the lamp'. At the same time, they adopted the argument put forward in the report on the January mine experiment that the fan switch chamber was an 'obvious source of ignition combined with an unlikely explosive mixture'. In other words, they said that it was impossible to say how the gas entered the starter-box or stayed around the back of the fan, and so the fan as the culprit was also only speculative. This, of course, was an invitation to say that I have failed to find, after a long and exhaustive Inquiry, what triggered the explosion that took 14 lives.

The argument put forward is a fallacy and a piece of sophistry which I reject. Having removed the lamp from suspicion, largely by the very failure of numerous tests to propagate an ignition through known defective lamps combined with a completely unconvincing set of circumstances as a hypothetical setting for the lamp to ignite the gas, there remains only one possible culprit - the fan starter-box."

Later in his report he said:-

"I am therefore left, as a result of the whole of the evidence, with the conviction that the explosion began by an ignition in the fan starter-box. I do not suspect that the deputy's lamp contributed in any way to the explosion. Indeed, having studied in detail the investigation of safety lamps, their defects and their inability, despite those defects, in most cases to propagate flame externally, I believe that reports of overseas explosion in mines where safety lamps have been indicated as

the cause, should be treated with great reservation now: they would need careful re-examination to determine what was really amiss with the suspect lamp and how it was known that it propagated externally."

In summing up, he further stated:-

"My finding necessitates a finding of gas in the starter-box and around the back of the fan. I am unable on the evidence to say in any precise manner how this collected, there being no eye witnesses and the evidence itself having been largely destroyed by the explosion. The following means are, however, open on the evidence:-

(1) The failure of adequate ventilation of 'B' stub, because of the nonremoval of the No. 3 cut through brattices.

(2) A possible failure of ventilation due to an occurrence such as a fall in a stopping outbye.

(3) The substantial leakage in the overcast and through 'B' heading stopping creating a serious deficiency of air available to the 'B' heading fan.

(4) The failure, deliberate or accidental, of the 'B' heading stopping."

Coroner Hiatt (1980) apart from his findings as to cause of death stated:-

"I have spent considerable time on my deliberations concerning the question of the source of ignition and referred to many aspects both in support and against each of the alternatives advanced. Other alternatives were excluded on consideration of the evidence and another raised by Mr. Lloyd as to a spark caused by friction on the use of the steel wedge has been left up in the air, however, I have determined that such a proposition is less likely as a probability than the fan starter switch in B heading or the Oil Flame Safety Lamp in the possession of Mr. Rawcliffe.

If it was the former, then it is probable that some person now deceased was at fault. If it was the latter, such act or omission not being deliberate or without exercise of reasonable care, the cause of the ignition could have been without fault or accidental.

An examination of the evidence in respect of those two alternatives disclose:-

In one, the fan starter switch chamber, there was a higher probability of gas being present in explosive proportions with a readily ascertainable flame path to the face of the headings and in the other the Deputy's defective Oil Flame Safety Lamp, there is a higher probability of gas in explosive proportion being present with a readily exposed flame path (the vent tube or layering) with a less probable source of ignition than that available in the case of an alive electrical source.

In my view, neither can be responsibly excluded on the evidence before this Court.

The evidence adduced does not enable me to say what was the source of the ignition which caused the explosion of methane gas at the face of B heading. Therefore, I am not able to determine what was the proximate or direct cause of the explosion but I have concluded that there was a condition existing for a period of time whereby the B heading stub was not properly ventilated. The precise reason for that has not been disclosed on the evidence but on the balance of probability there is evidence that the acts and omissions of persons on the previous shift contributed to inadequate ventilation." (Kininmonth, 1981)

REVIEW OF RESCUE OPERATIONS

The rescue and recovery work carried out during the emergency was generally considered to be satisfactory.

The area was recovered without further undue incident and without any significant problem or injury to the personnel involved.

Those problems which did occur were mostly relatively minor but are discussed here and following review by the rescue station staff and committee resulted in some changes to operational procedures and provision of additional equipment.

PROBLEMS ENCOUNTERED

(a) At Rescue Station

(i) Information relayed from the Colliery by rescue station staff was inadequate for properly assessing the need for availability of fresh teams. As a consequence, more teams were in reserve at the station than were needed and were there for too long a time.

(ii) Additionally, too many teams were sent to the station by each Colliery causing local problems of providing sufficient food at that early hour of the morning, and the teams becoming somewhat jaded.

(b) At Colliery Surface

(i) Surface control did not explain adequately to the fresh air base officials some of the reasons for requirements and decisions.

(ii) Decision making by the surface control was seen by those underground as being occasionally too slow.

(iii) Not all trainees were checked by a doctor before going underground.

(iv) No particular official was designated as co-ordinating controller at the Fresh Air Base.

UNDERGROUND OPERATION

(i) Too many permanent corpsmer and rescue staff were underground at the start of the operation.

(ii) The rescue station Superintendent and the Colliery Undermanager remained underground for too long a period.

(iii) Underground operations were made more difficult by an inadequacy of suitable plans of the area showing ventilation, transport roads, conveyors, etc. Since overcasts and stoppings were disrupted, non-Appin Colliery personnel had difficulty in clearly understanding the plans available which lacked detail.

(iv) Considerable delay occurred in providing food, water, tea, etc., underground.

(v) Gas sampling did not provide a proper assessment of the situation as the result of samples mostly reflected a situation some time before.

(vi) The carbon monoxide tubes used for spot indication were too low a range (10-3000 ppm).

(vii) Insufficient air flow readings were obtained. Additional attention may well have shown earlier a lower than normal air flow in the area due to a disrupted stopping outbye.

OBSERVATIONS

(a) Communication

Communication presented some minor problems, telephone communication was adequate between the fresh air base and the Colliery Control Centre, however, its control could have been improved as too many people were involved in relaying messages.

All underground operations and reporting should be through designated officials. Every endeavour will be made in the future to fully brief both those persons underground and those proceeding underground.

(b) Decision Making

First control of the operation was assumed by the most senior Colliery Company Official (General Superintendent) and the Senior District Inspector upon their arrival at the scene within an hour of notification.

Subsequently, joint control was exercised by the most senior Colliery Company Official and the Chief Inspector upon his arrival some four hours after the explosion.

Individual matters such as checking personnel in and out of the mine, provision of supplies, control of the media, security, etc., were provided by officials of the Company who were senior colliery officials or persons well versed in such matters.

During the course of the rescue operation, the Corex Mine monitoring system was operating and analysing samples from the return airway systems adjacent to the upcast shaft. Unfortunately, a newly installed sampling line to the Red Panel return near K panel was destroyed in the explosion.

In addition, the Department of Mineral Resources Mobile Laboratory was brought to the mine and monitored the return air at the upcast shaft.

The Laboratory was also utilized analysing bag samples sent from underground.

Due to the time delay in drawing a sample through the length of tubing and equally the time taken for the passage of ventilation from the affected area to reach the surface of the Upcast Shaft, the analysis results were some half an hour or so behind the actual circumstances.

Underground draeger tube results and methanometer readings were more timely being relayed by phone from underground but were of limited value as the CO results were well outside the range of the tube. The information was related only to the immediate K panel area and did not contain ventilation quantity.

During the operation of continuing high CO result from both the Corex system and the mobile laboratory caused considerable concern to the controllers especially when such knowledge was a half hour behind actual circumstances. It appeared to indicate the possibility of a fire source somewhere in the longwall area.

Accordingly, a rescue team was required to explore the longwall gate roads to check the possibility of a fire in that area. This was one of the reasons for underground complaint as the exploration was not fully explained to persons at the fresh air base. Fortunately, a fire did not exist, however, due to rapid build up of methane in unventilated area the possibility of fire caused considerable problems to the controllers and gave some cause for hesitation it being felt necessary to slow recovery operations pending determination of a possible fire source.

Intrinsically safe mobile monitoring equipment has since been provided at rescue stations. This equipment is battery operated and is located outbye of the FAB where it draws a continuous sample to it through a tubing line run out to the position being monitored. Both methane, carbon monoxide and carbon dioxide units are available.

(c) Miscellaneious Matters

The operation was fortunate in having the resources of a large Company (Australian Iron & Steel).

Matters such as the control of persons onto the colliery premises was carried out by company security officers whilst the media was handled by the companies public relations section.

Hot food was provided to awaiting and returning teams by a Salvation Army mobile kitchen and a most important job was carried out by Councillors of the Department of Youth and Community Services. They had the difficult task of consoling distraught relatives.

CONSIDERATION OF MANAGEMENT OF EMERGENCY SITUATIONS

Following the Appin Colliery disaster, revision was made to emergency duty cards and procedures so as to improve communications and better define duties. (Appendix 2)

Notwithstanding, the main problem of management responsibility in emergency circumstances in New South Wales remains. In Appin and in previous emergency situations it has been the role of Senior Officials to assume control of the operation and the overall decision making.

The Mines Rescue Act requires that the Rescue Station Superintendent of the district in which the mine is located shall among many duties "superintend the work of the rescue corps or persons employed in rescue operations."

The Coal Mines Regulation Act, the main Act governing safety in coal mines required that the Manager of the mine "have full charge and control of all persons employed, and of all operations in, at or about the mine..."

Further, the Coal Mines Regulation Act empowers an Inspector to impose such "prohibitions or restrictions of whatsoever kind and whether conditional or otherwise, as appears to the Inspector to be necessary for the purpose of safeguarding the safety or health of the persons employed in the mine."

Present legislation therefore still places the responsibility for the safe operation of the mine on the Manager with an overriding right of the Superintendent of the Rescue Station to ensure the safety of the persons involved in the rescue operation.

The role of the Inspector is somewhat passive in that he must recognise a danger and serve notice accordingly, a somewhat difficult decision as there is already an amergency.

It is our opinion that the obligation of the Manager should be removed as he can rightly be considered to have his judgement impaired by emotional and other considerations, especially where loss of life is involved or workmen may be trapped.

The custom has been for a number of persons, generally being the most senior company officials and most senior Inspector at the scene together with the District Miners Union Safety Officer and the Rescue Station Superintendent to control the rescue operation. Fortunately, loss of life has not occurred in N.S.W. during any such recent recovery operations. No doubt if such were to be the case the subsequent Court of Inquiry may well be critical of the procedure or the question of responsibility. The authors view this symposium with considerable interest in order to determine a formula which would better suit the management of such crisis situations and point the way to a statutory settlement of our problems.

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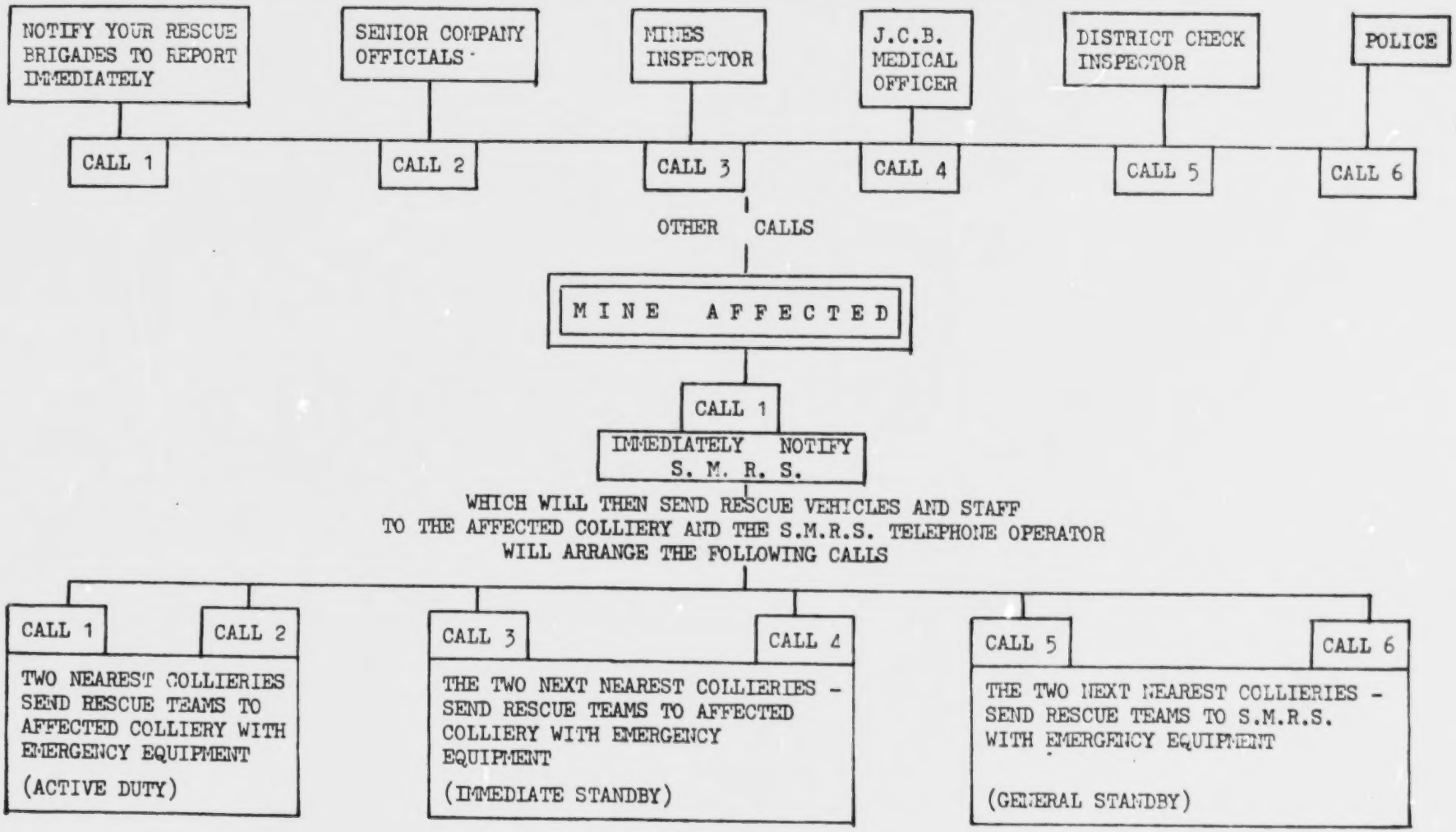
APPENDIX 1

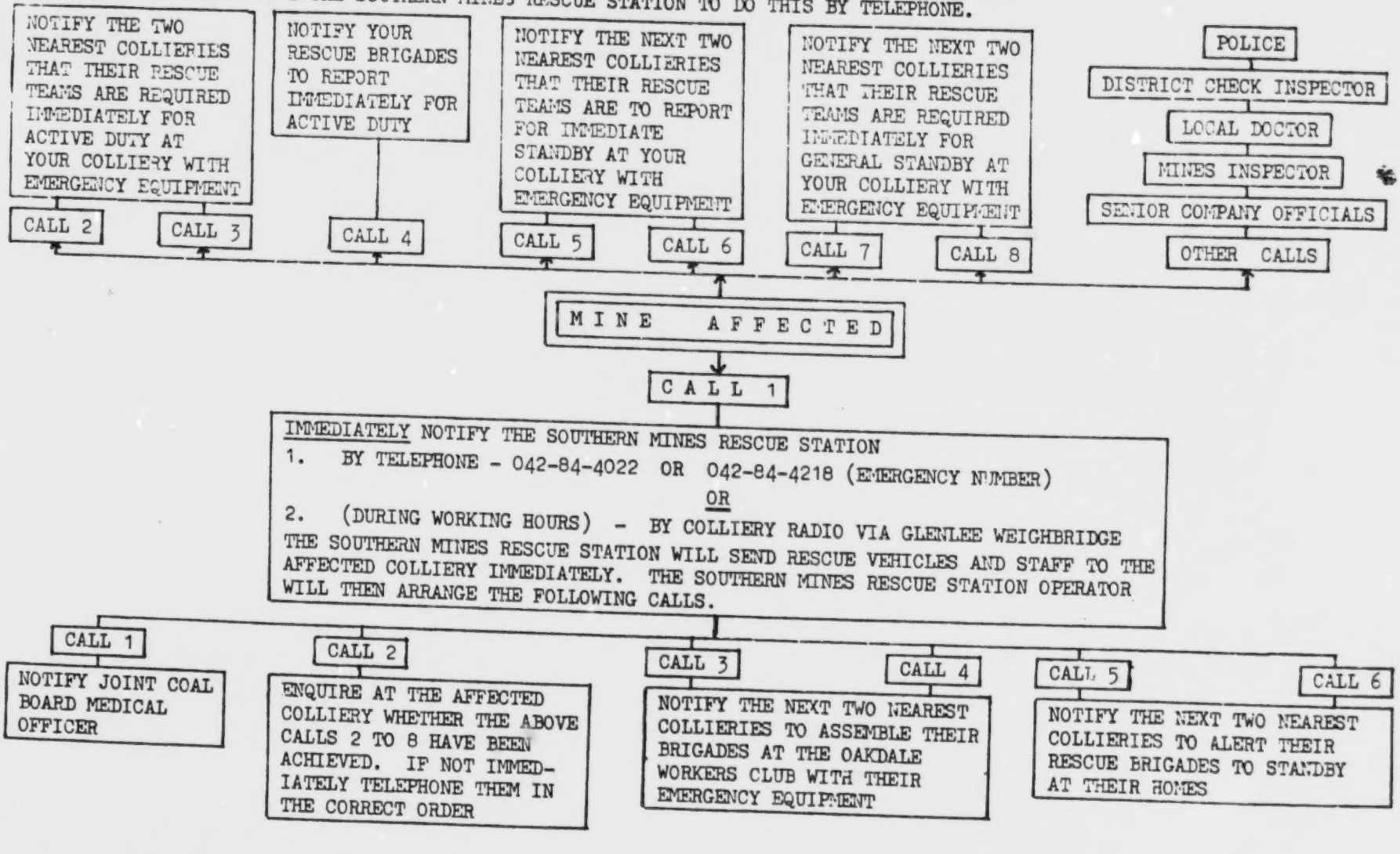
MINES RESCUE ORGANISATION - MUTUAL ASSISTANCE SCHEME - COASTAL COLLIERIES


NOTIFY YOUR RESCUE BRIGADES TO REPORT IMMEDIATELY
SENIOR COMPANY OFFICIALS
MINES INSPECTOR
J.C.B. MEDICAL OFFICER
DISTRICT CHECK INSPECTOR
POLICE
CALL 1
CALL 2
CALL 3
CALL 4
CALL 5
CALL 6
OTHER CALLS
MINE AFFECTED
CALL 1
IMMEDIATELY NOTIFY S. M. R. S.
WHICH WILL THEN SEND RESCUE VEHICLES AND STAFF TO THE AFFECTED COLLIERY AND THE S.M.R.S. TELEPHONE OPERATOR WILL ARRANGE THE FOLLOWING CALLS
CALL 1
CALL 2
TWO NEAREST COLLIERIES SEND RESCUE TEAMS TO AFFECTED COLLIERY WITH EMERGENCY EQUIPMENT
(ACTIVE DUTY)
CALL 3
CALL 4
THE TWO NEXT NEAREST COLLIERIES - SEND RESCUE TEAMS TO AFFECTED COLLIERY WITH EMERGENCY EQUIPMENT
(IMMEDIATE STANDBY)
CALL 5
CALL 6
THE TWO NEXT NEAREST COLLIERIES - SEND RESCUE TEAMS TO S.M.R.S. WITH EMERGENCY EQUIPMENT
(GENERAL STANDBY)

APPENDIX 1

MINE RESCUE ORGANISATION - MUTUAL ASSISTANCE SCHEME - BURRAGORANG COLLIERIES

CALLS 2, 3, 5, 6, 7 AND 8 TO BE ACHIEVED BY USING THE COLLIERY TWO-WAY RADIO SYSTEM DURING WORKING HOURS - OTHERWISE THE SOUTHERN MINES RESCUE STATION TO DO THIS BY TELEPHONE.


NOTIFY THE TWO NEAREST COLLIERIES THAT THEIR RESCUE TEAMS ARE REQUIRED IMMEDIATELY FOR ACTIVE DUTY AT YOUR COLLIERY WITH EMERGENCY EQUIPMENT
NOTIFY YOUR RESCUE BRIGADES TO REPORT IMMEDIATELY FOR ACTIVE DUTY
NOTIFY THE NEXT TWO NEAREST COLLIERIES THAT THEIR RESCUE TEAMS ARE TO REPORT FOR IMMEDIATE STANDBY AT YOUR COLLIERY WITH EMERGENCY EQUIPMENT
NOTIFY THE NEXT TWO NEAREST COLLIERIES THAT THEIR RESCUE TEAMS ARE REQUIRED IMMEDIATELY FOR GENERAL STANDBY AT YOUR COLLIERY WITH EMERGENCY EQUIPMENT
POLICE
DISTRICT CHECK INSPECTOR
LOCAL DOCTOR
MINES INSPECTOR
SENIOR COMPANY OFFICIALS
OTHER CALLS
CALL 2
CALL 3
CALL 4
CALL 5
CALL 6
CALL 7
CALL 8
MINE AFFECTED
CALL 1
IMMEDIATELY NOTIFY THE SOUTHERN MINES RESCUE STATION
1. BY TELEPHONE - 042-84-4022 OR 042-84-4218 (EMERGENCY NUMBER)
OR
2. (DURING WORKING HOURS) - BY COLLIERY RADIO VIA GLENLEE WEIGHBRIDGE
THE SOUTHERN MINES RESCUE STATION WILL SEND RESCUE VEHICLES AND STAFF TO THE AFFECTED COLLIERY IMMEDIATELY. THE SOUTHERN MINES RESCUE STATION OPERATOR WILL THEN ARRANGE THE FOLLOWING CALLS.
CALL 1
NOTIFY JOINT COAL BOARD MEDICAL OFFICER
CALL 2
ENQUIRE AT THE AFFECTED COLLIERY WHETHER THE ABOVE CALLS 2 TO 8 HAVE BEEN ACHIEVED. IF NOT IMMEDIATELY TELEPHONE THEM IN THE CORRECT ORDER
CALL 3
CALL 4
NOTIFY THE NEXT TWO NEAREST COLLIERIES TO ASSEMBLE THEIR BRIGADES AT THE OAKDALE WORKERS CLUB WITH THEIR EMERGENCY EQUIPMENT
CALL 5
CALL 6
NOTIFY THE NEXT TWO NEAREST COLLIERIES TO ALERT THEIR RESCUE BRIGADES TO STANDBY AT THEIR HOMES

APPENDIX 2

INSTRUCTIONS

THIS BOOK CONTAINS THE FOLLOWING SETS OF CARDS: -

1. DUTIES OF PERMANENT CORPS AND STAFF - PAGE 1
   - THIS MUST BE GIVEN TO RESCUE STATION OFFICIAL IN SURFACE CONTROL.

2. COLLIERY CONTROL CENTRE RECOMMENDATIONS - PAGES 2, 3 & 4
   - THIS MUST BE GIVEN TO COLLIERY MANAGER OR HIS OFFICER IN SURFACE CONTROL.

3. DUTIES OF MARSHALS AT COLLIERIES (PAGE 5) PLUS EMERGENCY TEAM ROSTER SHEET (PAGE 5A)
   - THIS MUST BE GIVEN TO SURFACE CONTROL WHO WILL GIVE TO MARSHAL WHEN HE ARRIVES. UNTIL THIS TIME, CAN BE USED BY RESCUE STATION OFFICIAL.

4. COLLIERY F.A.B. PROCEDURE - PAGES 6, 7 & 8
   - TO BE GIVEN TO OFFICIALS (S.M.R.S. OR COLLIERY) IN CHARGE OF F.A.B.

(1) APPENDIX 2

DUTIES OF PERMANENT CORPS AND STAFF

FIRST FOUR HOURS - ALL ON DUTY - SOME TO JOIN TEAMS FOR INITIAL EXPLORATION AND F.A.B. DUTIES.

THEN: 4 CORPSMEN
2 STAFF
1 CLERK
- GO HOME EIGHT HOURS

DURING THIS TIME:

STAFF - 1 AT F.A.B.
- 1 AT SURFACE CONTROL
- 1 CLERK AT STATION

PERMANENT CORPS - 1 AT F.A.B.
- 1 MONITOR
- 1 AT STATION
- 1 VEHICLE DRIVER

THEN SWAP OVER FOR TWELVE HOUR SHIFTS

NAME	TIME ON	TIME OFF	

APPENDIX 2

COLLIERY CONTROL CENTRE RECOMMENDATIONS

1. MUST BE SET UP WITH: -

	Check
a) Colliery plans	
b) Telephone communication underground and P.M.G.	
c) Two-way radio receiver (underground) when connected	
d) Gas Analyser Report Book	
e) S.M.R.S. Gas Monitor Recorders when set up	
f) Two-way portable radio S.M.R.S.	
g) Folders for Marshals	

2. SHOULD BE MANNED BY: -

a) Colliery Manager and/or Officer (particularly Under-Manager if available)

b) Rescue Station Superintendent or Officer

c) Company Official

d) Department of Industrial Affairs Inspector

e) Marshals

3. DUTIES INCLUDE: -

	Time Done	Initials
a) Get colliery electrician or engineer to connect R.S. U/G radio receiver and Gas Monitor Recorders into colliery telephone line both at surface control and P.A.B.		
b) Communicating with P.A.B. Officials and supervising operations. All information must be clearly recorded. The S.M.R.S. telephone bug should be set up at commencement of the operation by S.M.R.S. personnel. Care should be taken to change tape when necessary.		
c) Instructing: - 1) Surveyor for additional plans for teams		

(3) APPENDIX 2

	Time Done	Initials
c) ii) Confirm arrangements have been made to get supplies of brattice, tools, battens, etc. underground		
d) Arrange issue of two-way radios to Marshals, colliery gate guard, official (or person) checking persons leaving for underground		
e) Co-operate with Marshal so that teams can be briefed on arrival at Colliery re operation		
f) Arrange for accommodation of brigades with Marshal for briefing & resting. A large plan must be available for Marshal (Surveyor to arrange this).		
g) Organise a public relations official (A.I. & S. can arrange this) and a press briefing room to issue PREPARED statements. This official or Police should be used to advise any relatives of workmen injured or otherwise. If a relatives' waiting room is required this should be obtained.		
h) Canteen arrangements should be made. It is imperative to get food, tea and fresh water underground to F.A.B. as soon as possible.		
i) Communication with Police Rescue Squad should be made if mortuary required.		
j) If bodies are found then unless any danger to rescue workers results from leaving them there, the Police or departmental photographer should photograph them before moving.		

(4) APPENDIX 2

	Time Done	Initials
j) Police Rescue Squad should be asked for carrier bags for bodies if a few involved. The Rescue Station vehicles have disposable gloves and these should be sent to the F.A.B.		
k) Draw Up A Roster for Manning Of: - i) Control Centre ii) Marshals (check with Rescue Station) iii) F.A.B. Control iv) Public Relations Officers v) Surveyors, lamp men and surface staff - on say 12 hour basis initially		
l) Make sure liaison by radio or personally is made with Department of Mineral Resources Officers manning Mobile Gas Laboratory. They must be kept closely briefed on the gas monitoring.		
m) The F.A.B. must be notified when any brigade goes underground even if in a different part of the mine.		
n) Ensure the Rescue Teams are relieved at regular intervals - arranging transport to and from the Rescue Station. (Refer Marshals Roster Sheet)		

(5) APPENDIX 2

DUTIES OF MARSHALS AT COLLIERY

TWO PER SHIFT ON 12-HOUR BASIS

1. Marshals should obtain two-way radio from S.M.R.S. Staff.
2. Collect names and times of all trainees arriving and departing from Colliery.
3. Keep record and time of teams leaving for underground and returning on Emergency Teams Roster Sheet.
4. Liaise with Surface Control Officials to ensure a regular rotation of teams at four hourly intervals.
5. Take arriving teams to briefing area and supervise accommodation, food, etc. Advice as to where to do this may be obtained from surface control. (A blackboard is desirable)
6. Obtain briefing of operation from surface control and inform brigades of this. The S.M.R.S. should also be notified of progress and possible likelihood of brigades required in future. This should be preferably done by phone on a regular basis (say every 30 minutes).
7. To ensure team Captains realise that it is their responsibility to keep their team and its equipment in tact at all times.

APPENDIX 2

EXAMPLE

EMERGENCY TEAMS ROSTER SHEET LOCATION: APPIN PIT TOP DATE: 31.11.75 DATE: ..... IN CHARGE: G. SYKES 8am - 4pm
J. SMITH 4pm - 9pm

In the case of prolonged emergencies, teams should be rotated at four hourly intervals.

	12	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	
U'GROUND									1. Appin A				4.				7.								
									2. Westcliff A				5.				8.								
									3. Tower A				6.				9.								
This information recorded on pit-top & relayed to Station at regular intervals																									
PIT TOP									4. Cordeaux A				7.				10.								
									5. S. Bulli B-A				8.				11.								
									6. Tahmoor A				9.				12.								
STATION									7. Appin B				10.				13.								
									8. West cliff B				11.				14.								
									9. Tower B				12.				15.								
This information supplied to pit-top by Station																									
HOME SHIFT									10. Cordeaux B				13. Darkes Forest A				16. Metrop. A								
									11. S. Bulli B-B				14. Old Bulli A				17. Coalcliff A								
									12. Tahmoor B				15. S. Clifton				18. Old Bulli A								

COLLIERY SEQUENCE (From Emergency Cards) - Appin, West cliff, Tower, Cordeaux, S. Bulli B, Tahmoor.

MARSHALS - To be given a folder with these sheets and sheets to list individuals names and time in and out. Also brief list of guide lines. Liaison with transport driver. Care for gear.

EMERGENCY TEAM MEMBERS

Name (Print Clearly)	Times				
	Arr.	Coll.	Go U/G	Ret. Surf.	Dep. Coll.

(6)

APPENDIX 2

COLLIERY F.A.B. OPERATIONAL PROCEDURE

GENERALLY ON EMERGENCY

3 RESCUE TEAMS TO F.A.B. - A. 1 - Operational Team
- B. 1 - Standbye Team
- C. 1 - Gas Monitoring Team

3 OTHER PERSONNEL - 1 Colliery Official
- 1 S.M.R.S. Official
- 1 S.M.R.S. Permanent Corpsman

DUTIES OF TEAMS

		Time Done	Initials
TEAM A:	Immediate inspection of affected area and carry out action according to state of emergency - should also take "Gas Bag" samples on first inspection (if explosion or fire)		
TEAM B:	Standbye Team for Rescue Team 'A'		
TEAM C:	Operational Procedure - Gas Monitoring Team In case of a fire, explosion, heating or outburst Team C is to: 1. Set up Gas Monitoring Equipment - outbye F.A.B. at the nearest stopping with access to the return heading of the affected are (or panel). One man (possibly a Permanent Corpsman) is to be stationed here continuously to read and record the Monitor results in the CO, CH_4, and CO_2 books. 2. One man to continuously read and record monitor. (Record Sheets contained in book provided)		

(7) APPENDIX 2

3. The remaining team members, under the direction of the team captain, must carry out the following duties: -

Time Done	Initials

a) Check the atmosphere with tube detectors to ensure the Monitor probes are in the best location. (Max. 50 metres away and not on an intersection).

b) Set up markers at this Monitor sampling point and at corresponding points in adjacent return headings.

c) Measure and record in this book air quantities at these points. Repeat every 10 minutes (or as instructed)

d) At the marked points, each 10 minutes (or as instructed), check for:

CO (tubes)
CH_4 (D6 or 510%)
O_2 (E12)
CO_2 (tubes)
Temperature - Wet or Dry

} - Record the information in Captains book.

If in radio contact with the P.A.B. and surface, the Captain is to pass this information on without delay.

e) Once sampling points have been established in each return heading, bag samples are to be collected for immediate dispatch to the surface. Label clearly ... location, date, time, brigade. Repeat every 20 minutes.

f) Bag samples must also be collected every 20 minutes in each return heading for analysis by the underground monitors, AGAIN, label clearly.

APPENDIX 2

(8)

DUTIES OF F.A.B. OFFICIALS

THE OFFICIALS IN CHARGE OF THE F.A.B. SHOULD: -

1. Record all information including calls (telephone and radio), instruction and composition of teams - gas sampling (both F.A.B. and from monitoring brigade in appropriate books.

   N.B. Both F.A.B. and Gas Recording Books (CO, CO_2 and CH_4) should be available at the F.A.B.

2. Protection against irrespirable atmosphere should be kept available at the F.A.B. for each official. Either a therapy unit or Draeger BG 174 is satisfactory for each person.

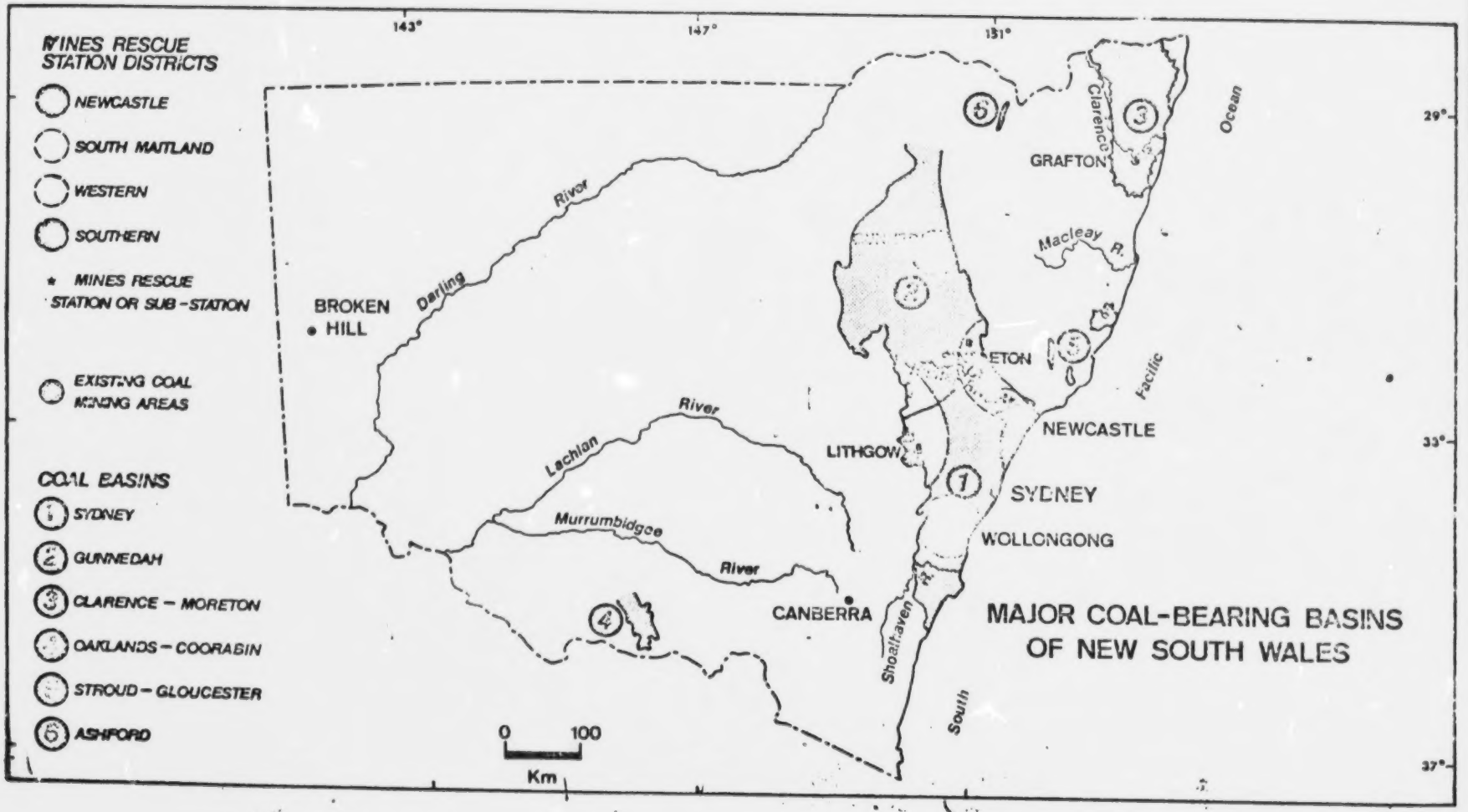
3. Arrangements should be made with Surface Control to have an electrician or engineer made available to: -

   i) Have the F.A.B. two-way radio base connected to cable to surface control.

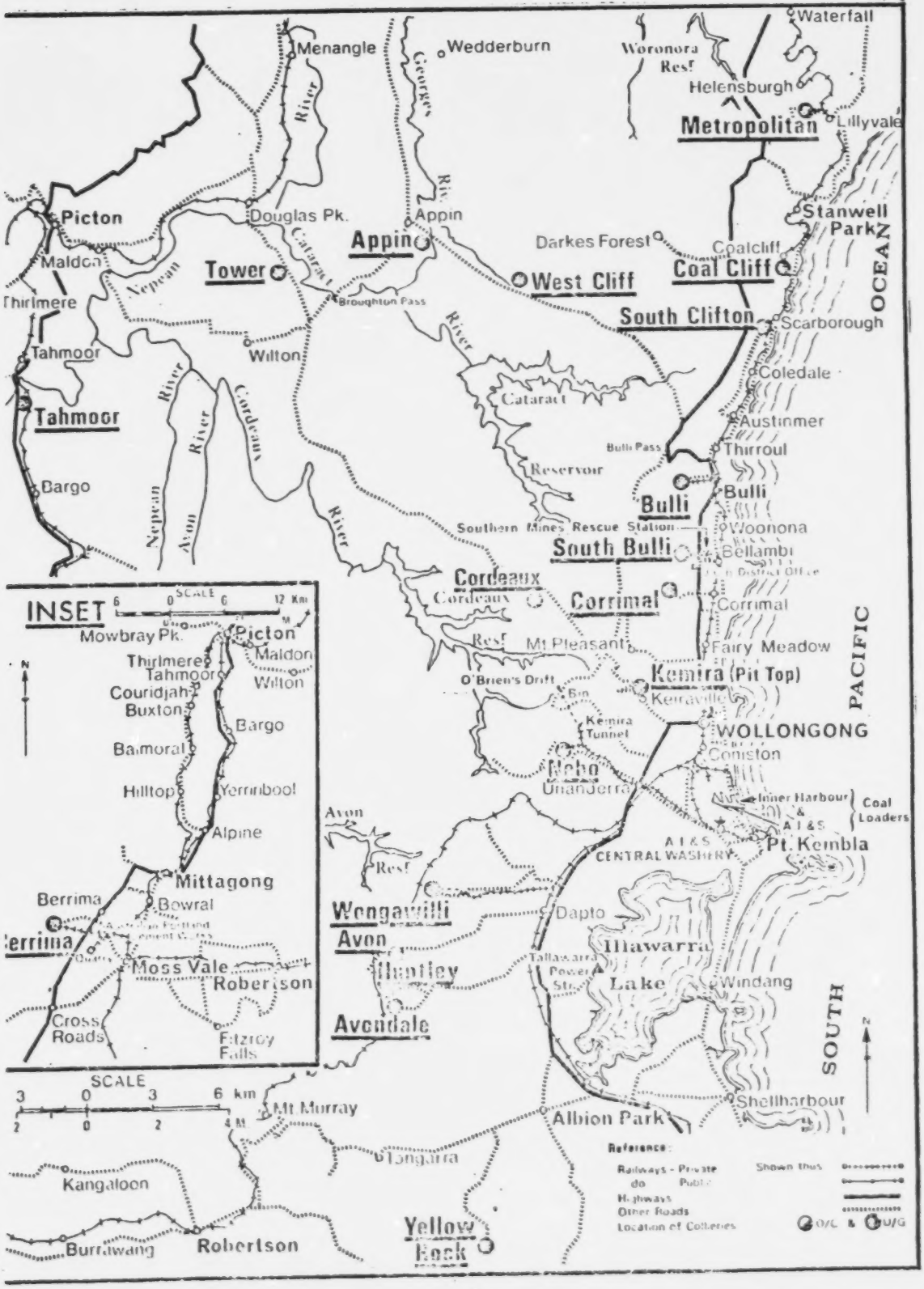
   ii) Have gas monitoring equipment connected to cable to surface control where it is to be connected to recorder.

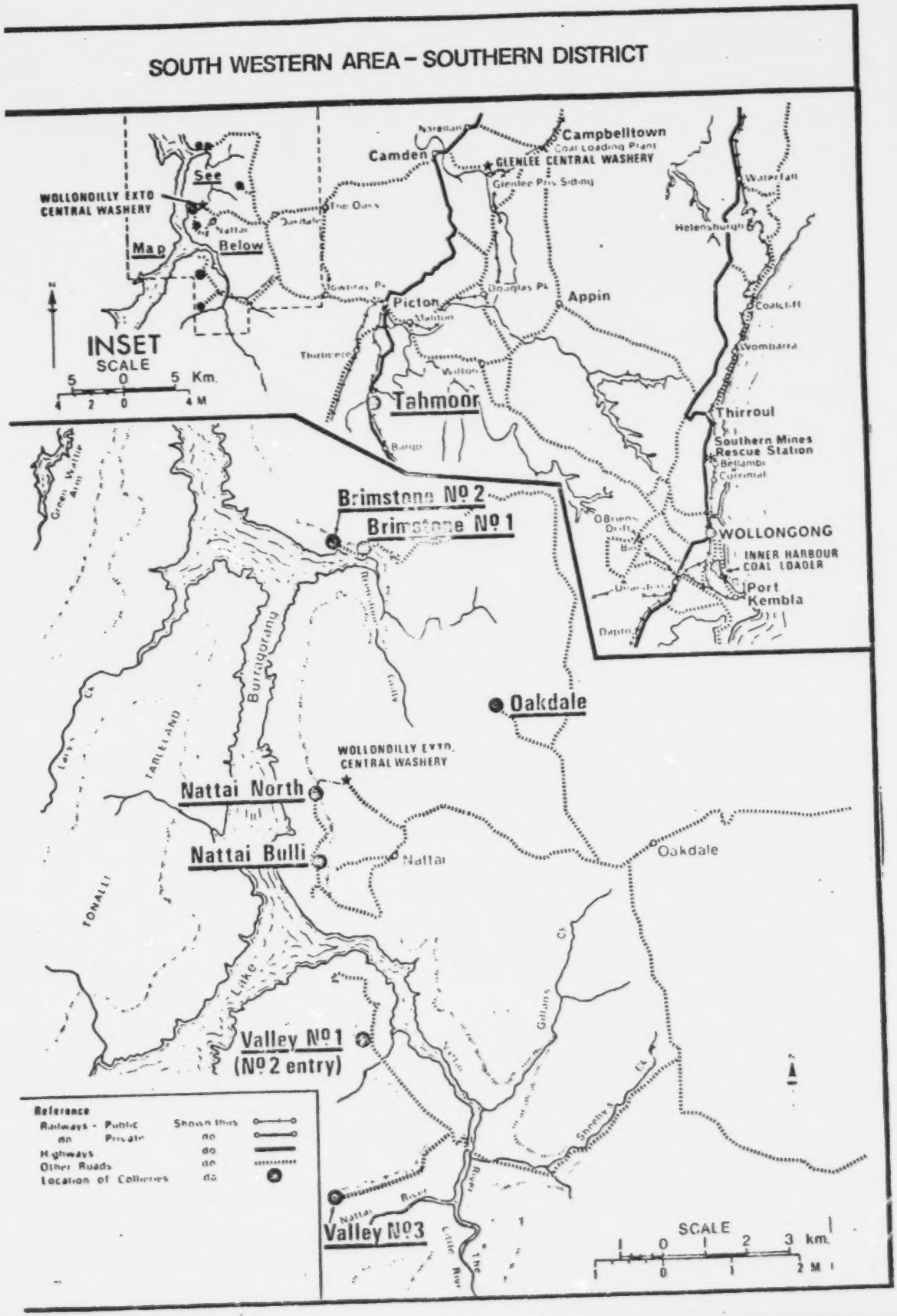
4. Teams arriving at the F.A.B. must be briefed on arrival on progress of operation, particularly with regard to plan orientation.

APPENDIX 3

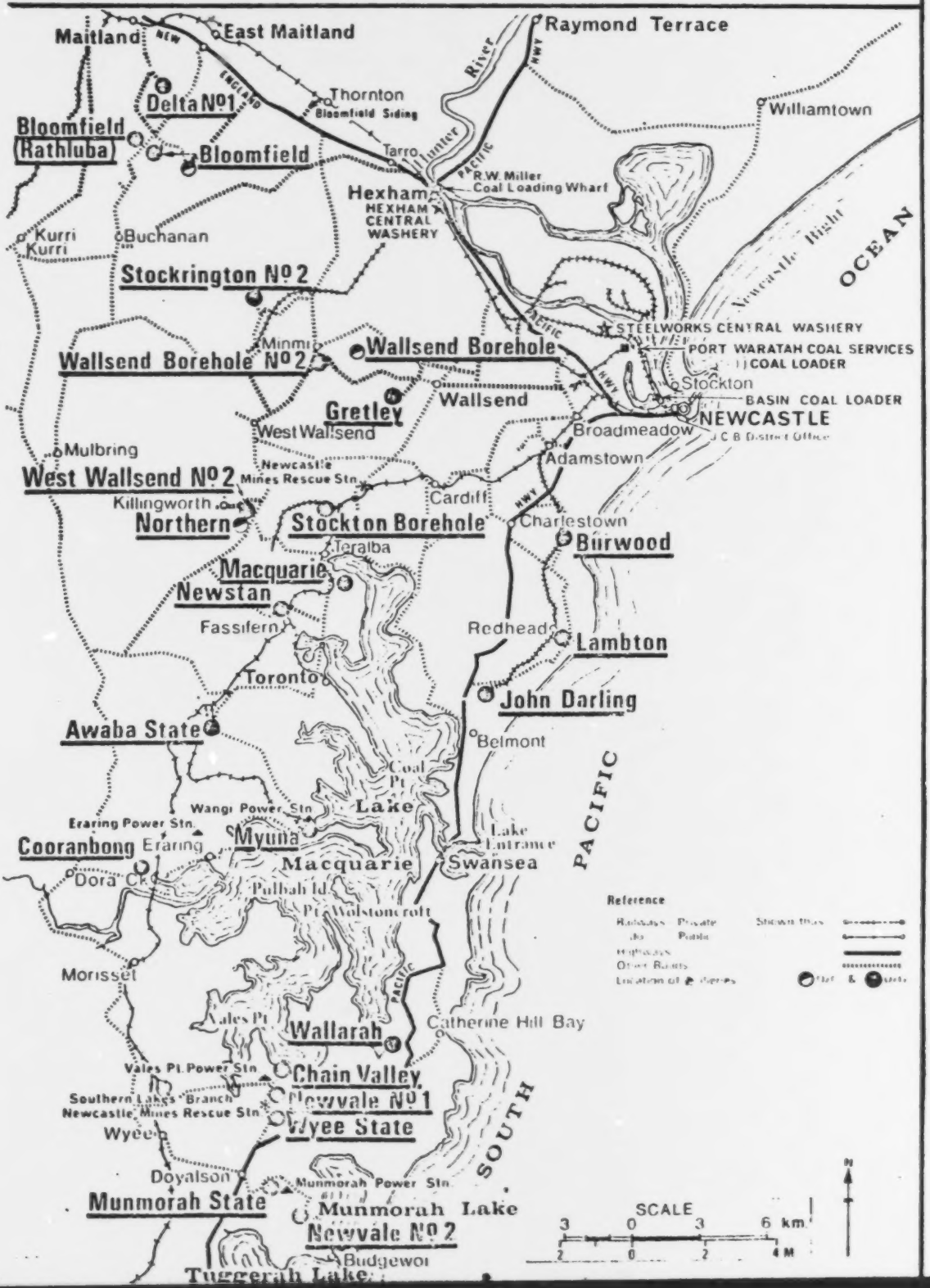

MINES RESCUE STATION DISTRICTS
NEWCASTLE
SOUTH MAITLAND
WESTERN
SOUTHERN
MINES RESCUE STATION OR SUB-STATION
EXISTING COAL MINING AREAS
COAL BASINS
1 SYDNEY
2 GUNNEDAH
3 CLARENCE – MORETON
4 OAKLANDS – COORABIN
5 STROUD – GLOUCESTER
6 ASHFORD
143°
147°
151°
29°
33°
37°
BROKEN HILL
Darling River
Lachlan River
Murrumbidgee River
CANBERRA
LITHGOW
NEWCASTLE
SYDNEY
WOLLONGONG
GRAFTON
Clarence
Macleay R.
Shoalhaven
South
Pacific Ocean
0 100
Km
MAJOR COAL-BEARING BASINS OF NEW SOUTH WALES

WOLLONGONG AREA – SOUTHERN DISTRICT




SOUTH WESTERN AREA – SOUTHERN DISTRICT
WOLLONDILLY EXTD CENTRAL WASHERY
See
Map
Below
INSET
SCALE
5 0 5 Km.
4 2 0 4 M
Camden
Campbelltown
Coal Loading Plant
GLENLEE CENTRAL WASHERY
Glenlee Pnr Siding
Waterfall
Helensburgh
Picton
Douglas Pk
Appin
Coalcliff
Wombarra
Tahmoor
Thirroul
Southern Mines Rescue Station
Bellambi
Corrimal
Brimstone No 2
Brimstone No 1
WOLLONGONG
INNER HARBOUR COAL LOADER
Port Kembla
Great Western Hwy
Bargo
Burragorang
Oakdale
WOLLONDILLY EXTD. CENTRAL WASHERY
Nattai North
Nattai Bulli
Nattai
Oakdale
Lake
Gillans Ck
Valley No 1
(No 2 entry)
Sheehys Ck
Nattai River
Valley No 3
Reference
Railways - Public
do Private
Highways
Other Roads
Location of Collieries
Shown thus
SCALE
1 0 1 2 3 km.
1 0 1 2 M

NEWCASTLE DISTRICT

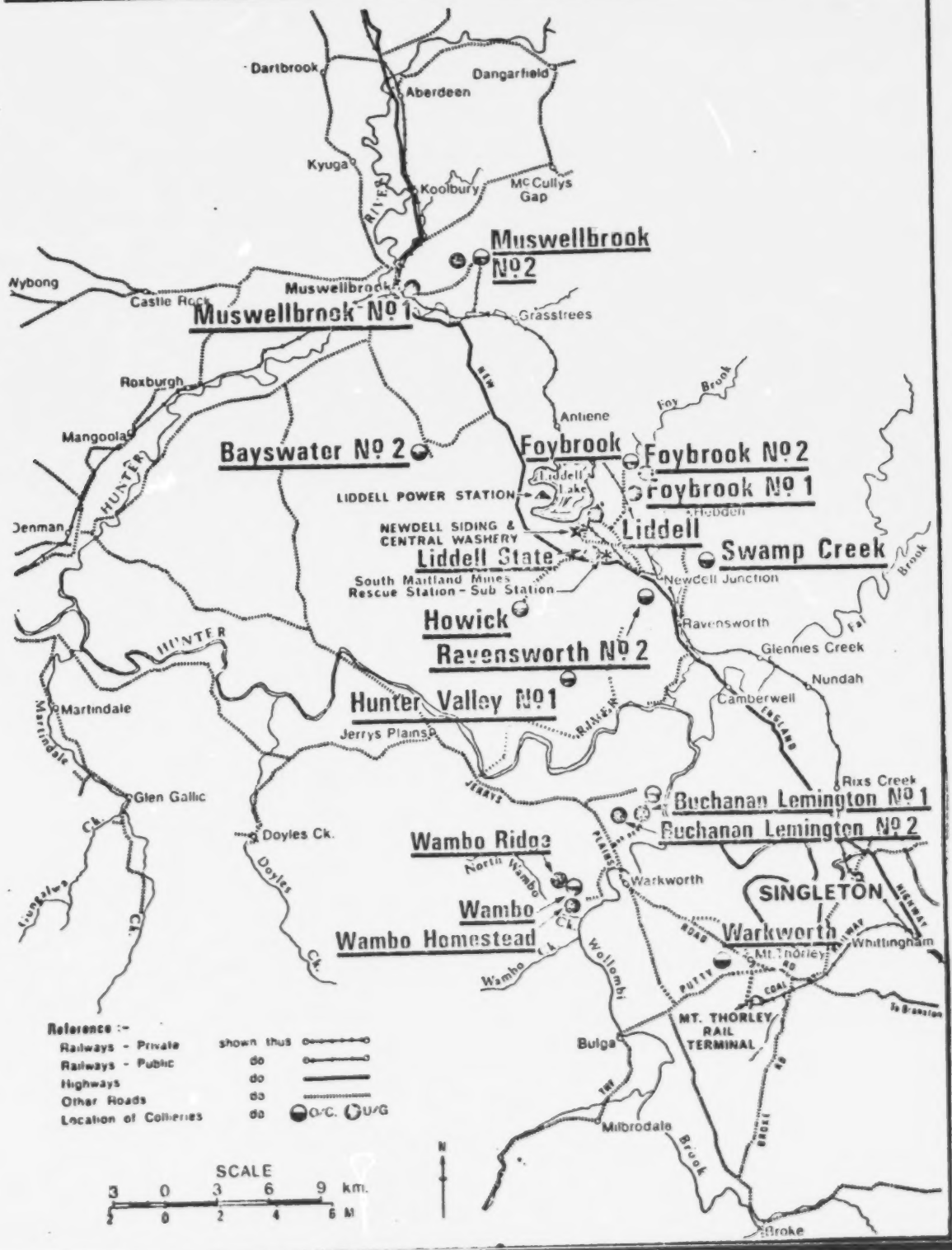


APPENDIX 3

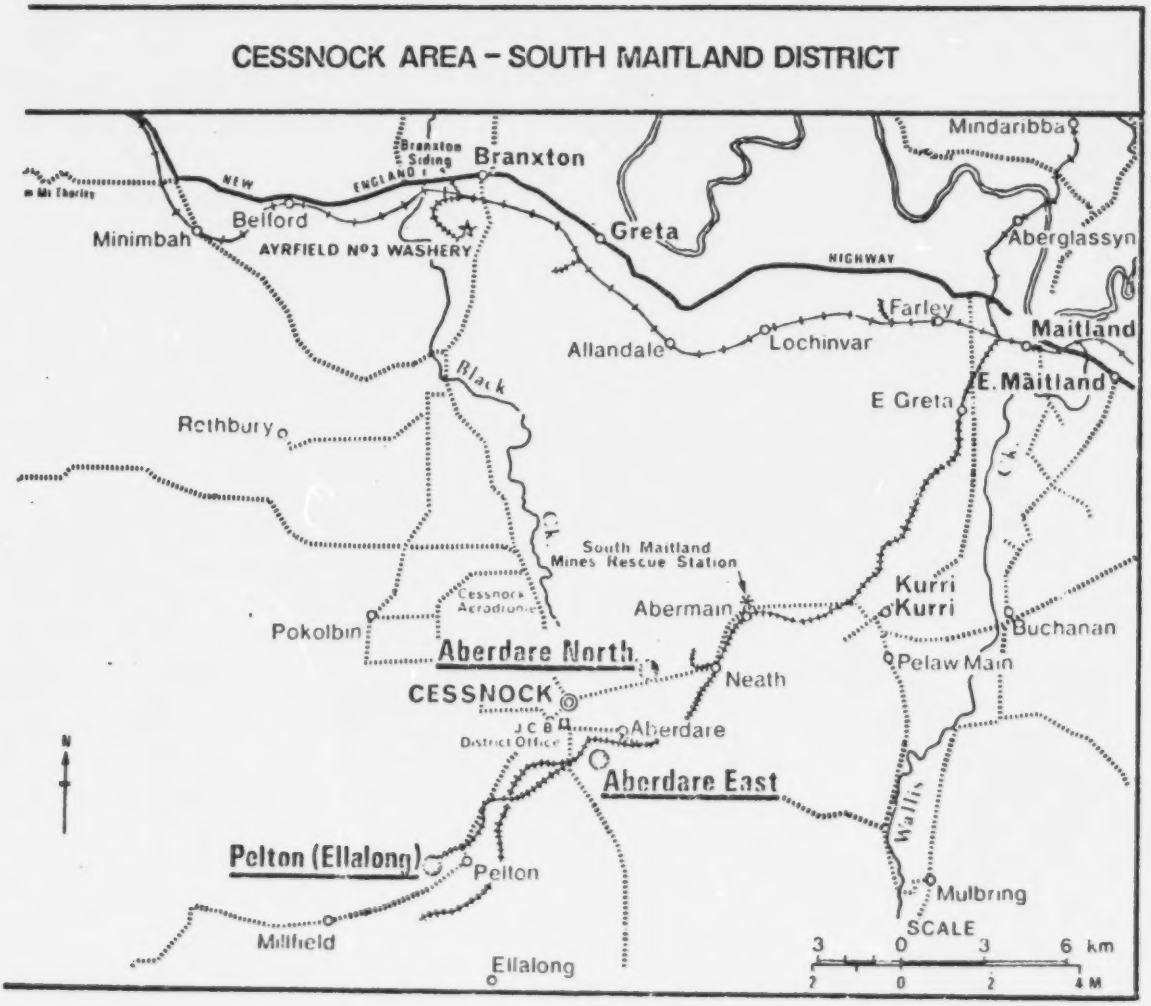
GUNNEDAH AREA - NEWCASTLE DISTRICT

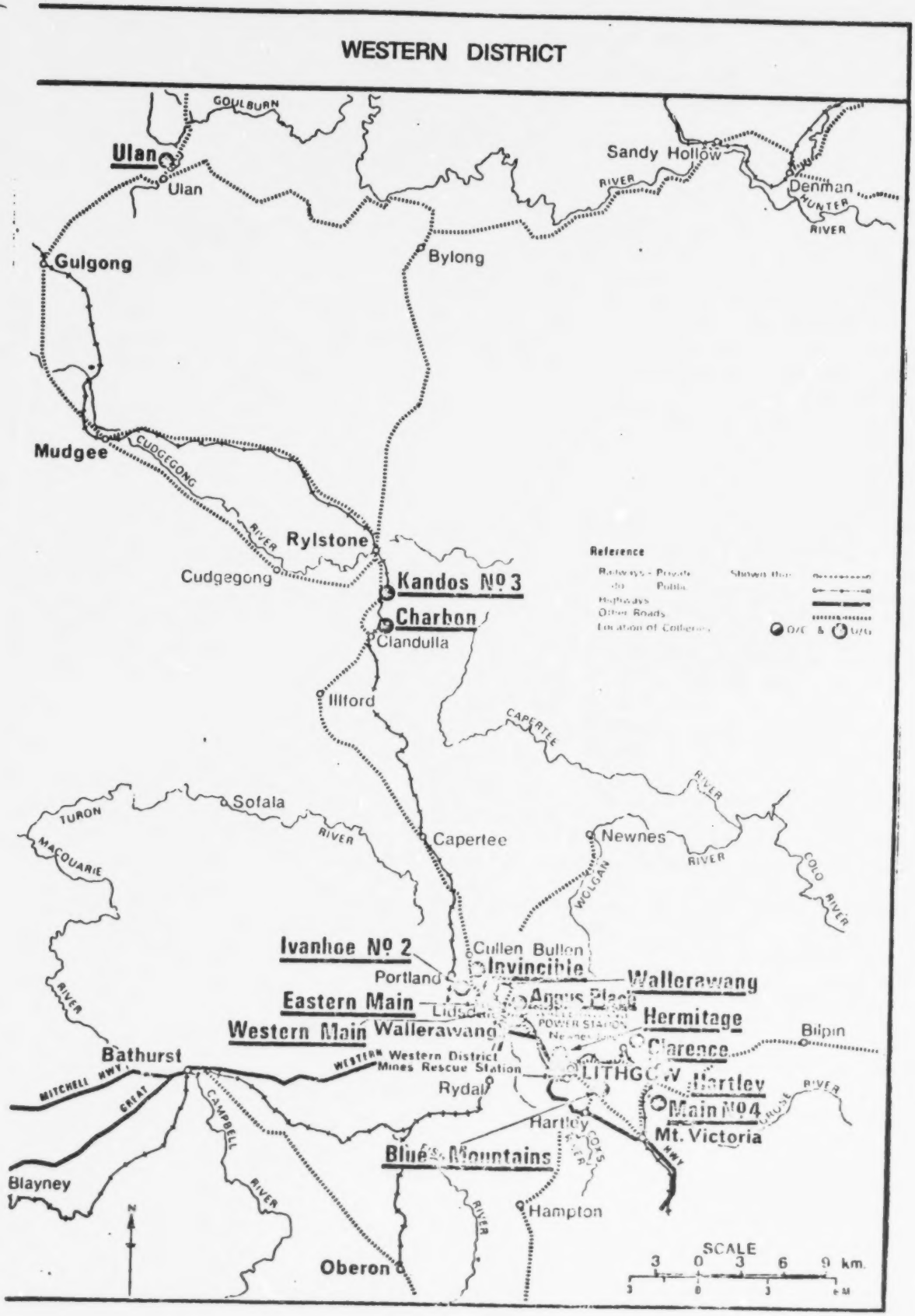
APPENDIX 3

SINGLETON AREA–SOUTH MAITLAND DISTRICT



APPENDIX 3


CESSNOCK AREA – SOUTH MAITLAND DISTRICT
Mindaribba
Branxton Siding
Branxton
NEW ENGLAND HIGHWAY
Belford
Minimbah
AYRFIELD No3 WASHERY
Greta
Aberglassyn
Farley
Maitland
Allandale
Lochinvar
E. Maitland
E Greta
Black
Rothbury
South Maitland Mines Rescue Station
Cessnock Aerodrome
Kurri Kurri
Abermain
Buchanan
Pokolbin
Aberdare North
Pelaw Main
CESSNOCK
Neath
JCB District Office
Aberdare
Aberdare East
Wallis
Pelton (Ellalong)
Pelton
Mulbring
Millfield
Ellalong
N
SCALE
3 0 3 6 km
2 0 2 4 M


WESTERN DISTRICT
GOULBURN
Ulan
Ulan
Sandy Hollow
RIVER
Denman
HUNTER
RIVER
Gulgong
Bylong
Mudgee
CUDGEGONG
RIVER
Rylstone
Cudgegong
Kandos No 3
Charbon
Clandulla
Illford
CAPERTEE
RIVER
Reference
Railways - Private
do Public
Highways
Other Roads
Location of Collieries
O/C & U/G
Sofala
TURON
MACQUARIE
RIVER
Capertee
Newnes
RIVER
WOLGAN
COLO RIVER
Ivanhoe No 2
Cullen Bullen
Invincible
Portland
Wallerawang
Eastern Main
Angus Place
Western Main
Wallerawang
POWER STATION
Hermitage
Clarence
Bilpin
Bathurst
WESTERN
Western District
Mines Rescue Station
LITHGOW
Hartley
MITCHELL HWY
GREAT
Rydal
Main No 4
Hartley
Mt. Victoria
CAMPBELL
RIVER
Blue Mountains
Blayney
Hampton
RIVER
Oberon
N
SCALE
3 0 3 6 9 km.

DISCUSSION FOLLOWING PRESENTATION OF M. J. MUIR AND J. STRANG

Q. Is the New South Wales Mine Rescue Service totally funded by industry levy?

A. Yes, totally by the industry. The Rescue Board set a levy on the industrial mines on a yearly basis. At the present moment it amounts to about eight cents per ton of coal mined in New South Wales. It is not worked on a tonnage basis, unfortunately, because that is the most equitable one but we can't do that because the Federal Government won't allow us. They claim that to be an excise and we can't do it constitutionally, so it is set on an unimproved capital value of the particular mines. The open cuts get the biggest slug and they have the least problems. But it is not that simple. It is based on an unimproved capital value of a particular mine and of course an open cut operation, which owns a large area of land generally have a much larger unimproved capital value and therefore gets slugged more. Some people reason that they can better pay, of course, but not the open cut operators.

Q. How are your mine rescue stations manned?

A. Each station is a little different. We man the station with a permanent staff on two shifts. We have to man the station 24 hours a day, seven days a week by the permanent staff, that is from the instructors up. We have five senior staff, they have to be on call. They have alarm bells in their homes, and they have to be on stand-by. Weekends they are allowed to leave their homes but they carry radios and paging units. But the station itself must be manned by a staff official twenty-four hours a day.

Q. Unrecorded question.

A. After hours, we generally can get them all but by law we are required to have at least two.

Q. Unrecorded question concerning ventilation at Appin Colliery.

A. That is exhaust ventilation. Yes. Yes. At the Colliery at the time of the explosion the colliery was being ventilated by an exhaust fan which was passing 225 cubic meters per second, which in old terms is 480,000 cubic feet per minute at one percent methane. You have to exhaust ventilate, of course, or you would only flood your intake roads with methane.

Q. What is the status of your radio communications equipment?

A. The equipment is now available off the shelf. We participated with Taiheiyo representatives in Australia about modifying the existing Taiheiyo radio equipment for our use. This is primarily a mobile base station. If you are interested, I have a rather lengthy report. A few people are not particularly familiar with radio equipment and if you are interested, you can have a look at it and if need be, I could possibly arrange to have a copy sent to you.

Q. How do the radios work? Do you need cables?

A. What we utilize with this is a very low frequency. Our tests show that if you have track work, conveyors, any lines you can pick it up right throughout the mine. Our emergency system is that we have an operational team, a standby team and we have a monitoring team. All these teams operate with radios. The teams that go where there might be disruption, they carry their own cable. This is only a light cable and they just drop it on the ground while they operate. They can go up to 50 meters away and the communication comes back perfectly. They can go without any communication, any cables at all, and we have a paging facility on the station and a paging facility on the surface control. You can recall that team from any where in the colliery with absolutely no middle work at all. The paging system is simply a matter of pressing a button and you get a tone call. We use the signal the same as we do for ordinary rescue work. If you want a team, and they are gone somewhere in the mine, you give them three for retreat, or if you just want their attention, you give them five.

Q. Unrecorded question concerning the inquiry into the Appin Colliery disaster.

A. No. After the explosion, there was what was called a judicial inquiry. A judicial judge was set up with a number of representatives. This inquiry dragged on for twelve months. There were two possible sources of ignition and the judicial judge said that it was one and that was the fact that the cover was off the starter box on the fan and they operated the fan when there was dust present in an unflameproof condition. The other alternative was that because of this, we got involved in an investigation old time safety lamps. The lamps involved were defective. We did a survey on 750 lamps and we found 150 defective lamps. We did reports amounting to something like 200 pages. There were four reports. We have a team of people, actually there were up to about 20 people, like professors in the universities, and very closely involved with other people. But the judicial judge for some reason would

not accept our reasoning. We demonstrated ignitions. In the lamps themselves, we found 16 defective gauzes out of the 100 gauzes. We followed this through with quality control of new component parts to the extent of going to the company in England and examing what type of quality control they have and we found that they have none. I made a rather lengthy report on this. Following this we got involved in a coroner's inquiry, that has to be set up as the result of anyone dying. The coroner gave an open finding. He said that it could have been one or the other. But there is no absolute proof because everything was destroyed.

Q. As a result of the Appin investigation, what have you done about flame safety lamps?

A. We made considerable revisions to the servicing of oil flame safety lamps thereafter. People now have the see through miscroscope type so that they can see the lamps, gauzes, etc. We found that the quality control on the glass was out too. The result is that the lamps are being much better maintained and so on. We have before us the possibility of throwing them out. We still await an effective proven oxygen detector. I think that is our main consideration now.

Q. What type of gas monitoring equipment do you use?

A. Usually a tube bundle system. We draw a sample to the analyzer. The Core-X one of course is the NCB production. But it is simply a tube bundle system. In the gassier mines they use some form of analyzer. It may not necessarily be a tube bundle system. Most of them are using the tube bundle system but they can use the Mahack system, which is a short tube and analyzed underground and transmitted to the surface.

Q. What is analyzed?

A. Methane and CO mainly. All return air ways in New South Wales coal mines which run over half a percent methane, have to be continually monitored. That is for methane, of course, and those that do it have a choice. There is no obligation to monitor the CO but most people also monitor the CO.

Q. What does the monitoring team do?

A. The monitoring team set up their analyzers just outside the FAB. Generally, we try to get a permanent staffman there. They can take up to 50 loads of tubing and they put that in at the first stopping. The team set up markers, assuming you got two or three returns, they have little triangular markers to indicate the spot. Initially, they take a bag sample from each heading. They also take CO readings with tubes. They take methane readings, oxygen and CO readings and they take the bags samples back to the FAB for the other headings.

They feed the samples that they pick up from the other headings through the monitors and send the other bag samples to the surface where the mobile lab had hopefully arrived. When we have our chromatograph, the chromatograph will operate from where we are monitoring operations as well. All these teams, when they take their instanteous readings, all on the radio control, it is recorded straight to the analyzer, straight to the FAB and straight to the surface, so there is a continuous record. We have three people keeping the same record. One of the big things we found out in Appin was that there records were chaotic. The other thing, this wasn't mentioned earlier but when you people get the paper you will appreciate it further, we made several changes. One was with equipment and one was with organization. This does not answer the question but perhaps other people will be interested.

If we have an emergency at a colliery, at all our collieries we have emergency cards set up. These cards are briefed with the minimum amount of things that the person has to do. So if a fire occurs in a mine, and a person underground is doubtful about something, he rings the surface and if a lampman or a fitter or an electrician or what have you picks up that, he immediately picks up a card. He rings us and we set out emergency system going. He had other set duties to do. That is what we have always done. That is similar to what they are doing in Sydney but we scaled down the practice because it is designed for a much larger task and we have smaller collieries. Once it hits the station, someone hits the controls and they pull out their emergency card, they ring the other stations and the other collieries and they ring the mobile gas lab and they all send teams to this colliery. We arrive at the colliery and what we do in my vehicle is I have a book of emergency cards, each other vehicle has identical cards. I get in touch with the service control and I give the service control officer a set of duties he must do. We get the FAB, give them a set of cards they must follow. We give the monitoring team their set of cards they must follow. Hopefully, then things will work out alright.

Q. Was methane drainage practiced at Appin?

A. At the time of the explosion there was no methane drainage being practiced. Presently there is but that has nothing to do with the circumstances of the explosion. The methane drainage was to be practiced at the next long wall at any rate. They drain as the wall retreats, they drain from behind the wall from the side road and they drain under seam. We don't drain above seam as it has been found not to be worth while. The main make of gas is from lower seams. In fact, the wall invariably as it gets its first wiping, will stand down for perhaps a day due to excessive gas that comes out of the floor in huge volumes. The ventilation is basically up both the side roads, both sides of the block, and return up around the shaft

back to the return air ways. No, there was no drainage at the time. There is drainage on the wall now but it has nothing to do with the ability to control gas on those development headings. We are trying to persuade the company by persuasive means, I guess, to drain across the proposed block to try and cover those headings by inseam drainage. They are experimenting with that now. Work to that extent has been successfully done at the adjoining colliery. They do in fact have inseam draining ahead of their development headings. But there is no obligation by law to do it at this point in time. They have simply got to keep below one and one quarter percent methane.

Q. Unrecorded question.

A. The rule is now that we have three people in charge of surface control. An officer from the station, the surface control officer would be in charge, but he must have a colliery official there and preferably one of their corps men as well.

The other point you are making is should they contact the team? I believe that all instructions to operational teams should be done by telephone to the FAB. The FAB control officer should have charge. But we have to realize that in Appin we had one situation where because of the rise in the CO content they notified us to withdraw teams. We had a team on exploration and it was too far, the sort of conditions didn't lend itself using the telephone. We had to send a team looking for the people of the team. We couldn't find the team. Finally, I had to take another team in and we found the team. Under those circumstances, I think the surface control officer should be able to contact everyone and order them to retreat. Now, you have to understand that we do not have one team but we have a monitoring team as well. Under those circumstances, I wouldn't expect the surface control to work through the FAB. But under any other circumstances, I would be very critical if they tried to by-pass the FAB.

UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

THE ROLE OF THE MINE EMERGENCY TECHNOLOGY TEAM

by

Robert G. Peluso

and

James L. Banfield, Jr.

Mine Safety and Health Administration
Pittsburgh Health Technology Center
Pittsburgh, Pennsylvania 15213

THE ROLE OF THE MINE EMERGENCY TECHNOLOGY TEAM

by

Robert G. Peluso[1/] and James L. Banfield, Jr.[2/]

ABSTRACT

When a mine emergency occurs, a district manager from the Mine Safety and Health Administration (MSHA) may require expertise and analytical equipment beyond the level that is available within his district. He may request the assistance of MSHA's Mine Emergency Technology Team (METT), a multidisciplinary group within the agency's Technical Support Directorate with expertise in gas analysis and interpretation, mine ventilation, and mine rescue and recovery operations. This paper examines some of the specific capabilities of the Mine Emergency Technology Team, as well as the role MSHA has during a mine emergency.

INTRODUCTION

The Mine Safety and Health Administration was established in the U.S. Department of Labor by the Federal Mine Safety and Health Act of 1977. The 1977 Act authorizes MSHA to perform numerous safety and health related activities; some of the major activities are to develop and promulgate regulations, conduct inspections and investigations, approve equipment for use in mines, and approve plans submitted by mine operators. Approximately 3000 MSHA employees administer the requirements of the Act from 4 main organizational units with responsibilities for coal mines, metal and nonmental mines, technical support, and administration throughout the United States. MSHA has established 10 coal districts, 6 metal and nonmetal districts, and 5 technical support centers. MSHA's administration functions are handled primarily by the agency's headquarters in Arlington, VA.

When an accident occurs in a mine, the regulations require that the mine operator must immediately contact the nearest appropriate MSHA district office. If the accident is an emergency, such as an entrapment, inundation, explosion or fire, the district manager will collect all available information and then immediately dispatch personnel to the mine site. The district manager will then implement MSHA's notification plan, first notifying the appropriate administrator in the Arlington office. The administrator will then notify the Assistant Secretary of Labor for Mine Safety and Health, and provide regular updates of available information. The administrator will also notify the director of technical support. The administrator's office and the technical support director's office will, in turn, notify necessary MSHA personnel, other government agencies, State agencies, miners' representatives, and other interested persons.

1/ Chief, Pittsburgh Health Technology Center
2/ Chief, Ventilation Division

The technical support director's first notification will be to activate the Mine Emergency Technology Team (METT). The METT provides technical assistance to the senior MSHA official, usually the district manager, at a mine emergency site. This technical assistance aids the senior MSHA official to issue orders as he deems appropriate, to insure the safety of personnel in the mine and to approve plans to recover persons or any portion of the mine and return affected conditions to an acceptable state. Of course, the orders and plan approvals are performed with the knowledge and cooperation of the mine operator, the representative of the miners, state officials, and other interested parties. The technical assistance provided to the senior MSHA official by the METT is in addition to that which is available in the district.

The special equipment and expertise of the METT is centralized in MSHA's Technical Support. Particular emergency situations call for different combinations and degrees of the following capabilities:

1. Logistic and procurement support;
2. Seismic location of trapped miners from the surface, in conjunction with or in lieu of underground efforts;
3. Large rescue-hole drilling capabilities;
4. Establishment of surface and underground communication systems;
5. Continual sampling and monitoring of mine gases at specified locations;
6. Analyses of gas samples;
7. Interpretation of gas sample results; and
8. Probing of boreholes using two-way communication probes and TV probes.

The METT, directed by the chief, MSHA's Pittsburgh Health Technology Center (PHTC), includes personnel from the center's Mine Emergency Operations, Ventilation Division, and Toxic Materials Division. In addition to their METT responsibilities, the team members have regular duties in their areas of expertise. However, when an emergency occurs, emergency activities are given top priority.

MINE EMERGENCY OPERATIONS

The Mine Emergency Operations (MEO) provides the METT with logistic and communication support, seismic location capabilities, borehole probing and the large rescue-hole drilling capabilities. MEO is located in

Hopewell, Pa., approximately 30 miles north of Pittsburgh, and is included in references to the term "Pittsburgh Station." The MEO chief, who is an electronics engineer, directs contract personnel from Westinghouse Electric Corp., and Rowan Drilling Co.

Westinghouse supplies three engineers and three technicians to the MEO activities in Pittsburgh on a day-to-day basis, during which time they regularly operate, maintain, repair, improve and test the seismic and communications equipment. Westinghouse also supplies two engineers and one technician located in Baltimore, Md., to manage and provide the logistic support for the MEO program. This contractual arrangement has proven beneficial because it provides up to 20 additional technical specialists from the Westinghouse Defense Center in Baltimore, and serves as a logistic and procurement command post once the personnel from Pittsburgh have been dispatched to the mine emergency site.

Rowan Drilling Co. supplies one drilling supervisor to the MEO activities in Pittsburgh on a day-to-day basis, during which time he regularly operates, maintains, repairs and improves the large hole drilling equipment. One engineer located in Houston, Texas, manages the program, and Rowan can provide up to 30 additional drilling specialists from various U.S. operations for emergency availability.

VENTILATION DIVISION

The Ventilation Division provides expertise to the METT in gas and airflow sampling techniques and in the interpretation of the results of gas sample analyses. The division maintains and operates instrumentation for continuous sampling and recording of mine gases, such as methane, ethane, carbon monoxide, carbon dioxide and oxygen. The division chief, who is a mining engineer, serves as the supervisor of the METT at the emergency site. He directs 14 mining engineers and three technicians who are knowledgeable in entire-mine and face ventilation systems, mine gas sampling and monitoring equipment. The Ventilation Division maintains computer models developed by the division and researchers from the Bureau of Mines, to assist in interpretation of gas sampling results with mine ventilation conditions. Also, new sampling equipment developed by the Bureau of Mines is tested side by side with the standard sampling equipment to determine its applicability to assessing underground conditions.

TOXIC MATERIALS DIVISION

The Toxic Materials Division provides the METT with analytical capabilities for determining concentrations of methane, ethane, propane, acetylene, hydrogen, oxygen, carbon monoxide and nitrogen. Analyses are performed using two gas chromatographs that, in an emergency, are placed in a van in Pittsburgh and the van is then driven or flown to a

mine site. The division chief, a chemist, directs one chemical engineer, two chemists, and two technicians, all of whom are proficient in operating the gas chromatographs. The gas chromatographs are maintained in the laboratories in Pittsburgh and kept operational. Upon emergency notification, the gas chromatographs are disconnected, packaged and placed in the van for transportation within a matter of hours. The Toxic Materials Division also conducts basic research on the development of analytical equipment to improve the quality, quantity and speed of gas analyses.

EMERGENCY RESPONSE LEVELS

A. First Level Response

The role of the METT can best be described by dividing the emergency response into three levels. During the first response level, which is stand-by, the METT begins preparing the equipment and vehicles for travel, and this normally takes from 2 to 3 hours. There have been over 40 first level responses in the last three years.

If the emergency occurs during regular work hours at the Pittsburgh Station, the team stops all other work, and preparation begins immediately. If the emergency occurs during off-work hours, members of the METT are contacted at their residences and, upon notification, proceed to the Pittsburgh Station to begin equipment and travel preparations.

While the team makes stand-by preparations at the Pittsburgh Station, other first level response activities are in progress. The Westinghouse operations center in Baltimore, Md., checks on the availability and schedules of commercial, charter and Air Force aircraft. The center's staff also reviews locations and inventories of vendors for such items as probe-hole drilling equipment and supplies, for which they keep a semi-annually updated list.

The director of the Pittsburgh Research Center of the Bureau of mines, is also notified and provided information. Potential equipment, services and personnel needs are discussed.

B. Second Level Response

During the second response level, which is deployment, the METT is dispatched from the Pittsburgh Station to the mine emergency site. The communication van, gas analysis van, supply trailer, seismic system truck and Ventilation Division van are deployed by road or air, whichever is appropriate.

Upon arrival at the mine emergency site, the Ventilation and MEO chiefs will contact the senior MSHA official on site to be briefed and make arrangements for deployment of vehicles and equipment. In most instances, the chiefs travel by aircraft ahead of the rest of the team, and when they arrive, there is minimum delay in getting into operation. During discussions with the senior MSHA official, an action plan is developed for the METT. Since the METT activities are primarily surface activities, the senior MSHA official and the chiefs develop the action plan in coordination with any underground activities and with the knowledge of the mine operator, representatives of the miners, state officials and other interested parties.

Since the team has been established, they have had 20 second level responses, some of which involved only part of the full team. Twelve of these responses have been required since October 1981. During the 1981-82 winter, three second level responses occured within a 2-week period.

C. Third Level Response

During the third response level, which is the deployment of the large rescue-hole drill equipment, the METT is already on site and trapped miners cannot be reached by underground rescue activities. They have been located and are in communication via a small-diameter probe hole.

The drill rig is then set up near the probe hole and proceeds to drill a large hole to rescue the miners. The use of the large hole drill rig occurs several days after the first notification of a mine emergency. The drill rig has been deployed twice since it was built in 1970 and has never been used in the rescue of a trapped miner.

METT ACTIVITIES DURING TWO MINE EMERGENCIES

Two mine emergencies that required a second level response illustrate the role of the METT. The first example is Mine A, which illustrates an underground sealing operation. The second example is the sealing and subsequent reopening of Mine B following an underground mine fire. In addition to its role during the emergency at Mine B, the METT also provided technical assistance necessary to reopen the mine. In both sealing and reopening procedures, the primary concern is the safety of persons either recovering the mine or rescuing trapped miners.

In November 1980, an underground explosion occured at Mine A. When the METT arrived at the site, they were informed that the bodies of the five men killed in the explosion had been recovered; however, efforts to reventilate the area of the mine (2 South-1 East) where the explosion had occurred, had been unsuccessful.

Following the explosion and subsequent recovery operations at Mine A, the decision was made to seal the explosion area from the rest of the mine. A set of seven seals were constructed across the 1 East entries to isolate the 2 South-1 East area from the remainder of the mine. During seal construction, a gas sampling line was placed in several seals so that samples of the atmosphere behind the seal could be collected.

Air samples are collected by pumping an air sample from behind the seal into an air sampling chamber. The sampling chamber is designed so that a vacuum bottle air sample can be taken without contaminating the sample. Figure 1 shows a schematic of the air sampling train. The vacuum bottle is analyzed by chromatagraphic methods and interpreted by the METT. Interpretation of the sample consists primarily of an analysis of sample explosibility and trend analysis by graphing sample concentration versus time.

Figure 2 shows a daily plot of the explosibility based on effective combustible versus the effective inert as the gas mixture behind the No. 5 seal at Mine A passed through the explosive zone. The December 2 sample, which had a methane concentration of approximately 15 percent, was well out of the explosive zone because the effective inert was approximately 10 percent. Also, the gas mixtures following the December 2 sample fall in the "explosive when mixed with air" zone. The decay path that the gas mixture would take when mixed with air can be found by drawing a straight line between the gas mixture composition point and the origin of the graph.

Similarly, the path of the composition point when an inerting gas, such as nitrogen or carbon dioxide, is added to the gas mixture can be found by drawing a line from the gas mixture composition point to the "0 percent combustible-100 percent inert" point on the graph.

When the sealed volume is small, it may be possible to inject enough inert gas into the sealed area to move the gas mixture composition point into the non-explosive zone. In any event, the addition of an inert gas to a sealed area moves the mixture composition point down and to the right. This would reduce the range through which the gas is explosive when the area behind the seal is reventilated.

Once the gas mixture within the sealed area passes through the explosive range, a plot is maintained of the concentration of various gases versus time. Figure 3 shows the methane concentration within the sealed area as a function of time. Also shown on the graph are lines representing calculated methane concentrations based on a 15 cubic feet per minute (cfm), and 20 cfm methane liberation rate within the sealed area. The buildup of methane in a sealed area can be closely approximated by mathematical models designed for that purpose.

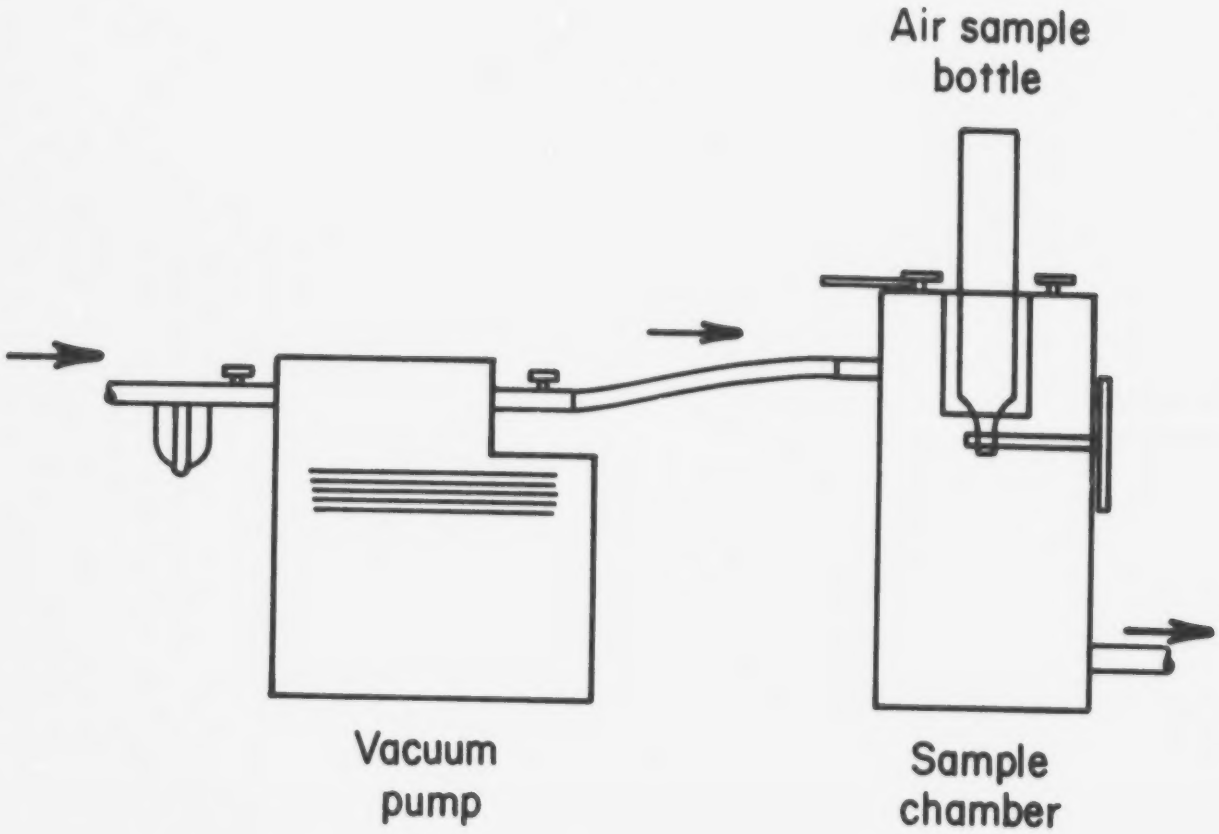


FIGURE 1. SCHEMATIC OF AIR SAMPLING TRAIN

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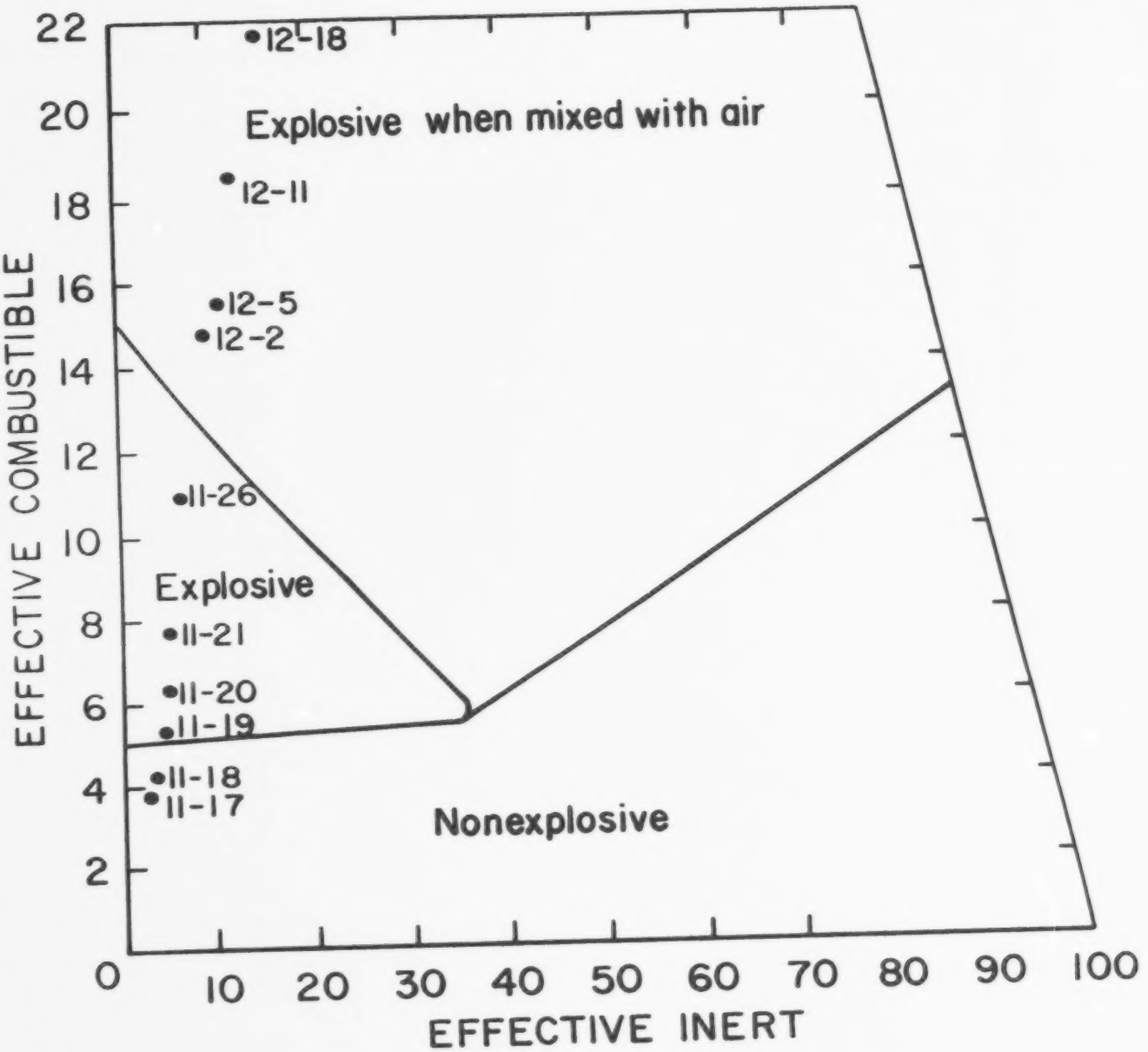

FIGURE 2.

PLOT OF EFFECTIVE COMBUSTIBLE VERSUS EFFECTIVE INERT FOR GAS MIXTURE IN SEALED AREA

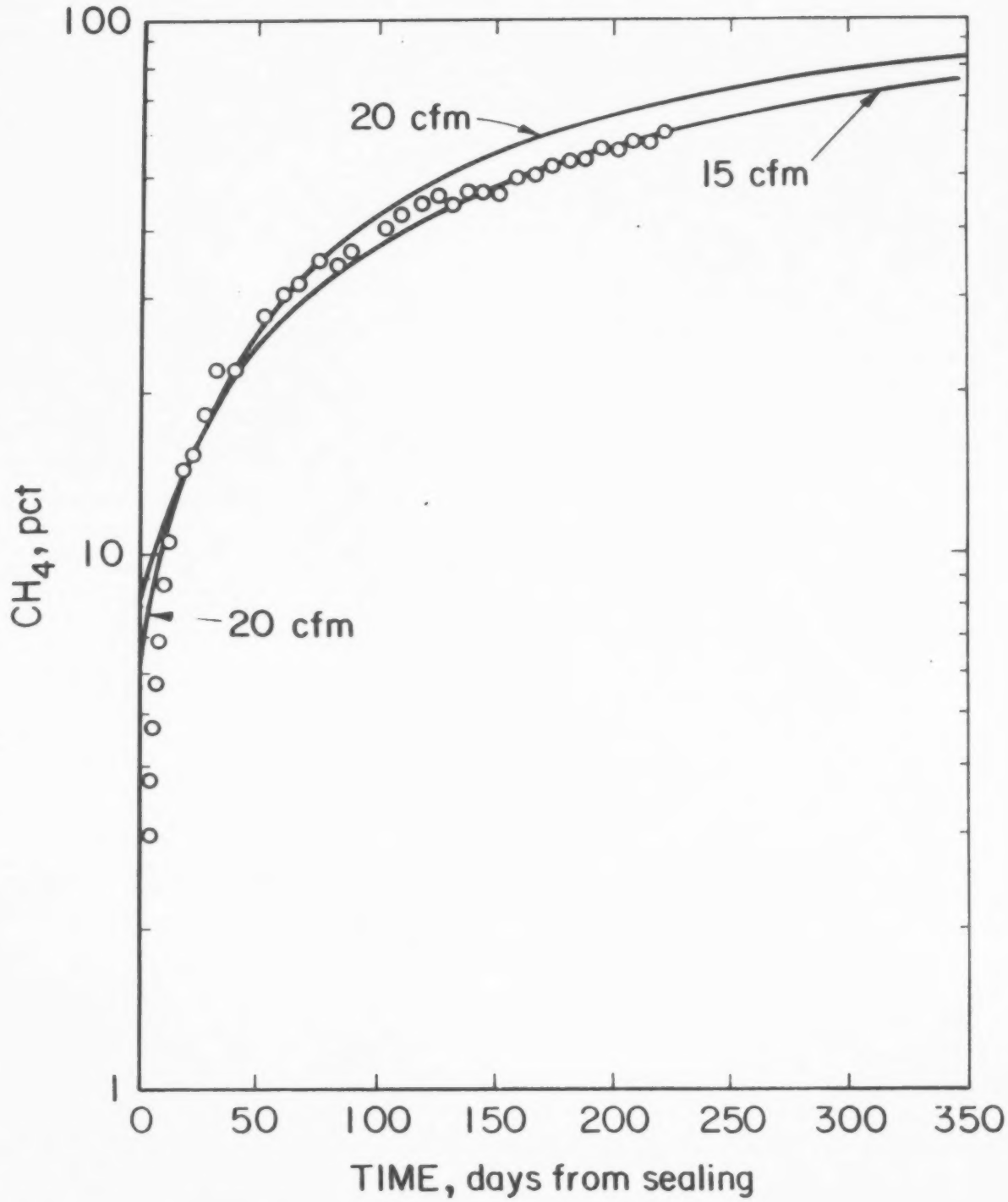

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FIGURE 3.

PLOT OF METHANE CONCENTRATION VERSUS TIME FOR GAS CONCENTRATION IN SEALED AREA

This area in Mine A has remained sealed since the explosion. Air samples continue to be collected weekly, and they are evaluated by concentration versus time plots of methane and oxygen.

About one year later on November 25, 1981, an underground fire broke out at Mine B. The mine was accessed by six vertical shafts ranging in depth from 1000 to 1200 feet. All attempts to extinguish the fire underground were unsuccessful, and on November 26, 1981, the decision was made to seal the mine at the surface. The mine remained sealed until March 6, 1982, when reopening procedures were started.

During sealing operations, air sample collection lines were placed in each of the shafts. An air sampling program was developed and Figure 4 and 5 show plots of gas concentration data that were maintained by the Ventilation Division personnel. The plots show the methane, oxygen and carbon monoxide concentrations at "F" Shaft during the period when the mine was sealed.

The arrows on the plot indicate when nitrogen was pumped into the fire area through vertical boreholes that had been drilled from the surface. Nitrogen was pumped into the fire area in an attempt to cool the fire. The air samples did not show any immediate effect of the injection of nitrogen. Since the fire had been extinguished by the time the mine was reopened, the absolute effect of nitrogen injection into the fire area could not be determined.

Semi-logarithmic graph paper is used for the plots, so that gas concentrations covering several orders of magnitude can be plotted conveniently on the same graph. In general, as the methane concentration increased, the oxygen concentration decreased. The carbon monoxide concentration decreased due to absorption by the coal bed, indicating a decline in the progress of the fire. Also shown is a plot of the carbon monoxide oxygen deficiency ratio index versus time. The trend of this index appears to be a more sensitive indicator of the state of a fire than the absolute value of the carbon monoxide concentration.

The decision was made to reopen the mine after it had been sealed for 100 days. This decision was based primarily on experience at other mine fires in the area. Analysis of the gas samples did not indicate anything to adversely affect this decision.

During the reopening activities at Mine B, the METT monitored gas concentr ions at shafts and fans in use during the various phases of the oper_ctions. This was accomplished by pumping samples from the various shafts or fans to a sampling station. Using non-dispersive infrared or electrochemical instrumentation, the METT was able to monitor the exhaust gases from the mine continuously for carbon monoxide, carbon dioxide, methane and oxygen.

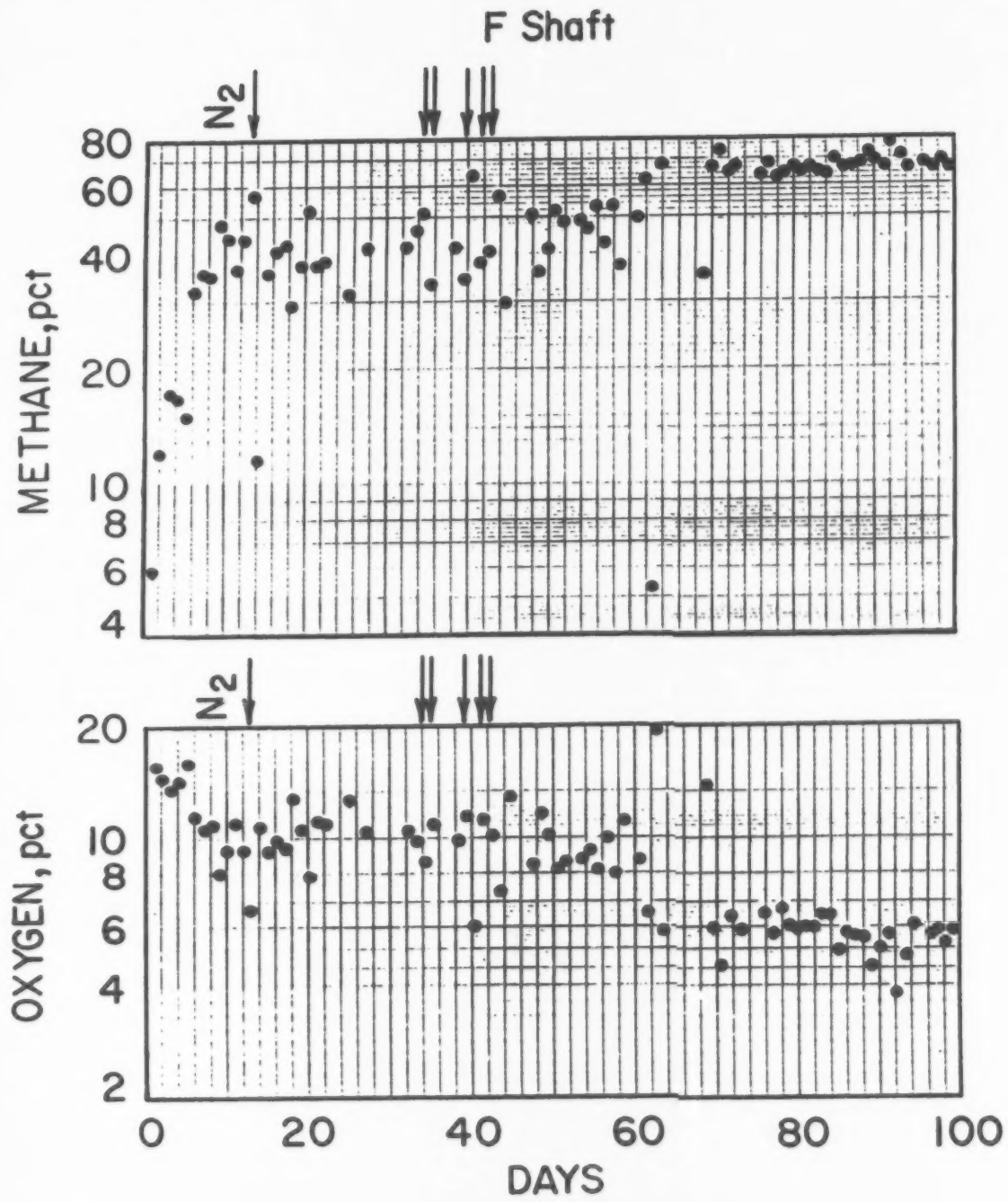

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FIGURE 4.

PLOT OF METHANE AND OXYGEN CONCENTRATION VERSUS TIME FOR GAS CONCENTRATION IN SEALED MINE

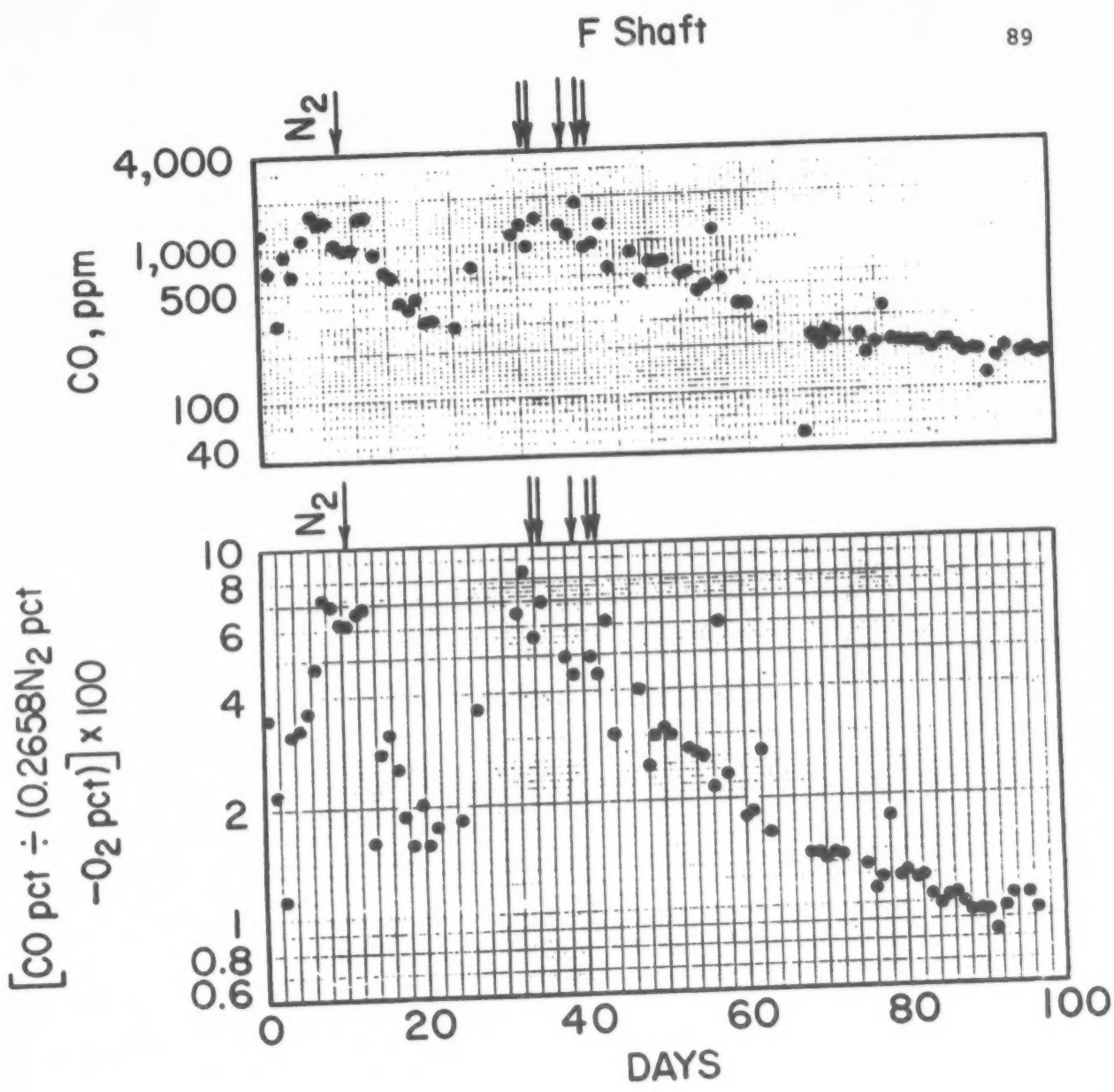

FIGURE 5.

PLOT OF CO AND CO-OXYGEN DEFICIENCY RATIO INDEX VERSUS TIME FOR GAS CONCENTRATIONS IN SEALED MINE

Over the 4-day period that it took to purge the methane from the mine, the METT continued their work. Various areas of the mine were ventilated by using the intake and return shafts in different combinations. The final intake and return shaft combination returned the mine ventilation system to its original configuration. After the mine rescue team explored the fire area and determined that the fire was out, METT removed the monitoring equipment from the shafts.

SUMMARY

Under mine emergency conditions, the confusion that develops can often be a detriment to the rescue and recovery operations. The technical expertise and experience of the Mine Emergency Technology Team in dealing with the various situations and alternatives that arise during a mine emergency lend to the successful completion of the job without sacrificing the safety of those individuals performing rescue and recovery work. The analytical and technical ability of the METT assists the responsible officials in recognizing and correcting potential hazards before they get out of control, thus benefiting the entire mine emergency operation.

DISCUSSION FOLLOWING PRESENTATION OF R. G. PELUSO and J. L. BANFIELD

Q. Greg Smith, Alberta

Who gets the bill for the three stage emergency? Is it federally funded or operator funded?

A. The maintenance of the system is funded by the federal government. The salaries for the people are already included in our budget projections. We have programs that we plan to conduct and will conduct if there are no mine emergencies. The maintenance of the mine emergency equipment, the drill rigs and the seismic is again funded by the federal government. It costs roughly $180,000.00 to maintain the drilling equipment and about $600,000.00 to take care of the other seismic communication equipment and television camera. When an emergency occurs, the cost for all federal employees is borne by the federal government. Many activities associated with the emergency, when determined by the district manager as necessary (meaning he needs to know that information), are paid by the federal government. There are activities that are not necessary, but the mine operator might want them performed. In those particular cases, the mine operator will have them performed, then he will pick up the tab. In some instances, we will permit him use of our equipment. If a mine operator asks for the use of the equipment because similar equipment is not available to him, then we have an arrangement where he can pick up the tab for it. He enters a contract with the people who are our contractors, and he only agrees to refurbish the equipment to the same level it was when he got it. I should mention that in the seismic equipment, we normally run 4 tests per year on seismic locations. We periodically run joint studies with the Bureau of Mines on some of their research work, which you will hear about tomorrow.

Q. Pat Phalen, Nova Scotia

What are the combined efforts between government agencies and companies in underground operations?

A. In the United States, the primary responsibility for rescue and recovery is with the operator. The operator is required to maintain a mine rescue team and if he doesn't have enough workers at his mine to do that, he is allowed to enter into a consortium of some sort where mines and rescue teams are available. The mine operator has to show that he has mine rescue teams available to him. Prior to this regulation, MSHA had four mine rescue teams, two in coal and two in metal and nonmetal. Since the implementation of this regulation, those mine rescue teams are no longer in existence. When an emergency occurs, the mine operator calls out mine rescue teams and they go to the mine. There are state laws and there are federal laws, with the federal laws over-riding, in most instances. However, in instances where state laws are more stringent, then they are over-riding.

A. Continued

What we try to do is get the cooperation of everybody involved at the mine site; all the interested parties (the mine operator, the representatives of the miners, states, the federal government, and any local or other interested parties). We try to get that cooperation and develop an action plan and proceed from there. The district manager does have the authority to supervise and direct rescue operations if he so chooses. But normally, he does not exercise that right, he just ensures that people aren't going to be hurt and approves plans accordingly.

MAIN ASPECTS OF THE METHODS AND ORGANIZATION OF DISASTER RESPONSE IN FRANCE

BY

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- and -

J. DANGREAUX, Ingenieur General des Poudres,
Director of Research Department at Cerchar

Presented by

D. CARIVEN, Director at Charbonnages de France

1. COAL MINING IN FRANCE

The production of coal in France is ensured by mainly three coal fields:

- The Nord-Pas de Calais coal field, in the north of the country;
- The Lorraine coal field in the north east;
- The Centre-Midi coal field which comprises several scattered mines in the quarter south east of the country.

The activities of these coal fields are coordinated by a central organization: Charbonnages de France.

In 1981, French production of coal was 21.5 Million tonnes of saleable coal in total of which 4 Mt. in Nord - Pas-de-Calais, 11 Mt in Lorraine, 5.5 Mt in Centre-Midi, 1 Mt in miscellaneous workings.

The personnel of the whole organization of Charbonnage de France was 58,500 people of which 30,000 were employed underground and 28,500 at the surface, including surface mines, as well as power plants and coking plants operated directly by Charbonnages de France.

The deposits that are mined by the different mines are most diversified in many aspects, namely:

- by coal quality which ranges from anthracites to bituminous coals and lignites.
- by the steepness of the seams which varies from 0 to 90^{o}.
- by seam thickness which varies from .7 metres to more than 10 metres with sometimes massive accumulations of coal.
- by the self heating characteristics of the seams which can be practically nil in some deposits but very important in others.

In order to control the safety hazards likely to be encountered in such diverse coal deposits, Charbonnages de France in close cooperation with CERCHAR, have developed systems for preventing, detecting and responding to such hazards, as well as for protecting personnel.

Five fields of intervention, where actions were most significant and the solutions adopted most beneficial to safety are presented hereafter.

2. PREVENTION OF HAZARDS RELATED WITH BELT CONVEYORS

It is well known that belt conveyors present particular hazards because they are a possible source of heating by friction and are likely to transmit a fire due to their continuity and their length.

A first level of protection of belt conveyor systems is obtained by selecting the materials which constitute the belt itself. Strict specifications have been established and only authorized belts can be utilized. Such authorization is delivered by the Administration after testing by CERCHAR; belts are subjected to a friction test on a drive; no inflammation must occur before breakage of the belt; also it is verified that a piece of belt after inflammation by an important source of heat (gas burner), does not propagate the inflammation in the presence of fresh air.

In addition, conveyors are protected against the consequences of possible slippage on the drive. Speed control systems monitor the speed of the belt and the peripheral speed of the drive, which must be equal and stop the conveyor in the event a slippage occurs.

A third level of protection includes the equipment of conveyor drives with temperature detecting systems, which monitor the possible heating of the driving drums, of the structure of the drive and of the belt itself. In the event of an increase in temperature, an alarm is issued and depending on local conditions, the conveyor is stopped and fire extinguishing is actuated.

These conveyor drives are equipped with a water spraying system which is controlled either automatically or manually; water is sprayed inside the drive as well as on the belt over a certain length and on both sides of the drive.

Finally, research work is being conducted by CERCHAR with a view to determining the nature and the quantity of products of thermal decomposition of the conveyor belts used. The results of this research will enable to select those belts, which present minimum risk and also to orient the methods of protecting personnel likely to be exposed to these products of decomposition.

3. DETECTION OF CARBON MONOXIDE AND OF THE PRODUCTS OF HEATING

One of the most effective methods of detecting a source of heating is to systematically monitor the CO which is produced by the heating.

Since 1962, Charbonnages de France have used for this purpose, UNOR units, which can be installed underground. These units enable to measure the content of CO in the atmosphere within a range of 0 to 300 ppm for the oldest units and 0 to 100 ppm for the most recent ones, which are currently most applied. Charbonnages de France currently uses 106 UNOR units in total in its mines.

Some UNOR units permit the monitoring of multiple points of measurement, i.e. 5 to 18, depending on the particular unit. In such cases, each point of measurement is connected to the UNOR unit by an individual flexible tube. A sequencing system connects each point of measurement to the UNOR unit at regular intervals. Also, it is generally possible to keep the unit interrogating in a particular direction, which is to be continously monitored for a lapse of time. The measurements collected by these UNOR units are usually transmitted to the surface, where they are displayed, recorded and processed. So the 106 UNOR units, currently in operation, monitor approximately 320 directions of measurement.

In the relatively sizeable mines, the large number of points of measurement do not permit effective monitoring by one operator without the assistance of a processing system, which produces an alarm in the event anormalous conditions arise. One particular difficulty occurs in some mines: on the one hand, manifestations of heating are associated with relatively low CO contents (several PPM only) and on the other hand, the circulation of locomotives and the use of blasting produce a base level of CO, which is of the same order of magnitude or even greater, than the anomalous contents that are to be detected.

The processing systems are designed to produce prealarm and alarm signals corresponding to levels in excess of preset figures for each particular direction depending on prevailing local conditions. In most cases, these pre-alarm or alarm signals are produced only in the case of repetition of the excess measurements, so as to eliminate unreliable or transient occurrences.

To investigate for an anomalous emission of CO within a base level of relatively high value, the system permits to look for the existence or non-existence of measurements <u>below</u> a certain level. If no periods at time are found which present such <u>low</u> measurements, e.g. periods of 6 or 24 hours, the atmosphere controlled can be suspected likely to be developing a heating condition and should be monitored specially, generally by direct control by an itinerant monitoring agent.

These systems also enable to store data with the possibility of direct retrieval which makes it possible to review the evolution of CO contents versus time at one or several points of measurement.

Finally, the system can transfer the data collected to another control station, which makes it possible for example to coordinate, if necessary, the actions taken in two or several mines having common ventilation sections.

4. AUTONOMOUS SELF-RESCUE APPARATUS (APEVA)

After the second world war, filter type self-rescuers were developed and made mandatory in most European mining countries and in the United States.

But these apparatus do not provide total protection of personnel; they are ineffective in atmospheres which lack oxygen or which contain toxic gases, in particular high contents of CO, or in atmospheres heated at high temperature. Filter type self-rescuers, therefore, give the personnel an illusory sense of safety, leading them to expose themselves to danger instead of escaping. Many accidents have occurred in such circumstances.

Filter type self-rescuers were therefore not imposed in France but, in cooperation with the Safety and Health Commission for the mining (Luxemburg), the French mine administration called for the development of autonomous self-rescuers. A first result was obtained in 1963 with the development of a compressed oxygen self-rescuer, i.e. the FENZY 63, which later became the FENZY 66; this apparatus was introduced in all underground mines which presented risks of spontaneous outbursts of gas (the apparatus being stored near the working faces).

A second stage of results was reached in 1977 with the introduction of a chemical oxygen apparatus of commercial use. Comparison tests on the apparatus available on the market, were conducted; at the same time, tests of reliability versus time, were conducted by CERCHAR, to examine the influence of the conditions of storage in the mine workings.

These units have proved capable of assuring the protection of personnel during approximately 90 minutes in escape conditions or 4 hours in survival or resting position. They can, therefore, be used underground as units serving the same purpose as filter type self-rescuers, but they present the greater advantage of remaining safe in atmospheres, where the filter is insufficient or ineffective and they permit a prolonged passive utilisation while awaiting rescue. Such a unit is a good autonomous self-rescuer, denominated APEVA an acronym of its French designation, i.e. APpareil d'EVacuation Autonome.

Immediately after the first conclusions of these tests, an allocation of 1000 units to the French mines permitted to equip for trial purposes a number of production faces, e.g. faces liable to spontaneous outbursts of gas, or equipped with diesel trucks, etc.

Experience acquired with the units in underground use and the promising results obtained as far as their reliability is concerned, led Charbonnages de France to considerably increase the allocation of such units for underground use; the additional units were stored in strategic positions of underground workings; these were selected by the management of each mine and their quantities correspond to the shift most loaded in personnel.

This new phase of equipment, now in full swing, should result in the allocation of nearly 4000 units for all the French mines.

However, the present units still present the disadvantage of being fairly heavy, so they cannot be used by personnel while working. Research is therefore under way in order to develop a much lighter type of equipment, which would lead to a much more extensive use of APEVA.

5. STABILITY OF THE VENTILATION NETWORK

Ventilation network disturbances likely to be provoked by heating in underground workings, were investigated a long time ago first by Budryk in Poland. Budryk's conclusions were generally qualitative and presented a great margin of uncertainty; moreover, his findings were not applicable to networks, where gases are circulating in descending roadways.

This research work was resumed by experts of the permanent organization for safety and hygiene in coal mines of Luxemburg. Mr. Simode, Chief Engineer of Houilleres du Bassin de Lorraine (the Lorraine coalfield) completed this study and made it applicable to the more complex cases. Moreover, recently, the calculation of ventilation network disturbances by heating was performed by computer processing in addition to the systematic calculation of ventilation networks, which is applied in all the French coalfields.

In order to be capable of using these calculations in the case of a heating, the air circulation characteristics of the ventilation networks must be kept up to date. Certain categories of personnel must also be trained to analyse situations arising due to a heating. In addition to the three specialists of the "Center for the calculation of ventilation networks", a number of responsible mining engineers and supervisory personnel participate to exercises during which the possible consequences of a heating are studied in a particular district, belonging to their actual mine; the exercises are conducted using on the one hand, mine plans and specific diagrammes/sketches, prepared for these studies and by processing various hypotheses of heating sources by computer calculations.

6. UTILISATION OF NITROGEN FOR INERTINISING THE ATMOSPHERE IN CASE OF A HEATING

Conventionally, the response to heatings of coal in underground workings, consists in smothering the fire by suppressing oxygen, i.e. by sealing off the access of air to the fire.

A new method of controlling a fire was introduced in recent years and has developed considerably. This is the utilisation of nitrogen, which is substituted more or less totally to air feeding the fire.

The range of conditions of application of nitrogen is very extensive indeed: it ranges from preventive uses to the direct control of fires, which have reached a more or less important stage of development, and to reopening mine workings.

The nitrogen used is a by-product of the production of oxygen, obtained by fractioned liquification and distillation. It is mainly available in liquid form, transported by tanks of 15 - 26 m3 capacity. It is converted to gas in fixed or mobile installations at the surface of the mines. It is then transported to the underground workings under a pressure of several bars, by means of pipes which can be, depending on the case, either installed permanently for this purpose or recovered from another place of utilization, or installed specifically for the purpose in which case flexible hoses are generally used.

Nitrogen is used for prevention when caol, generally in old workings, is liable to self-heating because it is difficult to suppress stray air leaks. The injection of nitrogen then permits to intertinise these stray air currents. The flow of nitrogen used in such cases, is of the order of several hundreds of m3/hour of expanded gas.

When a point of self heating starts to develop, the same method is applicable, but in such case, the flow of nitrogen used is several hundreds to several thousands of m3/hour expanded gas.

In the above two cases, it is generally not necessary to build sealing barriers to isolate the area in which nitrogen is being injected. However, it is obviously most advantageous to render as leak proof as possible by coatings or injections using materials such as cement, plaster, bentonite or synthetic raisn, the gate-end packs of a face, where air is likely to leak through, in addition to the application of nitrogen injection. The actual point of injection in the workings is reached by the end of the pipe. But in certain cases, it can be necessary for access, to drill bore-holes from adjacent roadways or mine workings.

If this action is not sufficient or if the fire is too important at the start, it becomes necessary to seal off the area by building barriers. Before the use of nitrogen, the construction of such barriers posed important problems: first, the barriers had to have a sufficient mass of material to resist a possible explosion, at least in the gassy mines; second, the barrier situated on the return had to be built as quickly as possible, in order to avoid creating a reversed circulation of air feeding the fire; so the construction of barriers on the return was a very delicate operation indeed.

The use of nitrogen has considerably modified this strategy. Indeed, it is now possible, by simultaneously controlling the flow of air into the area and the flow of nitrogen injected, to render the atmosphere in the area inert without risking to create an explosive atmosphere.

To attain this result, expanded nitrogen flows of 6,000 to 20,000 m^3/h and more can be required. Such flows can now be achieved. The barrier on the air-entry can consequently be considerably lightened; for example, it can be made using simply wooden planks and sealed by a plastic sheet. The construction of the barrier on the return can be delayed in time.

If it is not anticipated to reopen the area being isolated, the consolidation of the barriers built on the intake and return can be carried out in most favourable conditions of safety and cost. The sealing of these barriers can be most effective and the injection of nitrogen can then be stopped.

But if the area is to be reopened, either to recover equipment or to resume mining operations, or merely to reduce the extent of the isolated area, the use of nitrogen again provides a most safe solution.

A temporary reopening can be carried out by maintaining the workings in blind level and by injecting nitrogen to compensate for leakages; this creates a totally inert atmosphere and in such conditions, there is no risk that the fire will start again or still less that an explosion will occur.

If a permanent reopening of the area is to be made, the problem is a little more complicated. However, nitrogen again provides very favourable conditions for the answer. First it permits to achieve a totally inert atmosphere, which smothers the fire most certainly whereas a mere confinement of the area by barriers enables the fire to feed itself slowly using the oxygen contained in the area and the oxygen supplied by the leaks, which often cannot be suppressed totally. Second, the flow of nitrogen that can be maintained in the area, provided it does not favour parasite air intakes, cools the area of the fire and permits to expect, that after a certain lapse of time, it will be sufficiently cooled down to prevent it starting again after reopening of the district. It is still possible and cautious in such case to maintain the injection of nitrogen as a preventive measure to the area of this old fire.

7. CONCLUSIONS

The new methods that have been applied in our coal mines during recent years, some of which are still in the process of development, have considerably increased the conditions of safety vis a vis risks of heating or development of heating situations. These methods are still being perfected and research work is continuing with a view to developing new possibilities in this field.

DISCUSSION FOLLOWING PRESENTATION OF D. CARIVEN

Q. G. MacPhail, Ontario, on the subject of inerting with nitrogen, could CO_2 be used?

A. We find it easier to get nitrogen. For example, we can get all the nitrogen that we need within 10 hours. We are presently planning to install nitrogen inerting systems in all our collieries. We have made trials underground with inert gas generators but they did not produce enough volume for our needs. Nitrogen has been very successful in controlling self-heating or spontaneous combustion incidents in West Germany and France in recent years. Just last week we used nitrogen in one of our collieries when we detected a self-heating in the goaf. We try to use nitrogen very quickly in such instances to prevent the self-heating from becoming an open flame fire which could ignite methane in the goaf.

I was talking with a West German colleague last week in Belgium who told me about an explosion of gas in one of their collieries. The gas was ignited by a rapid self-heating in the goaf which was not detected by CO monitoring in the return.

Comment by F.J. Kock:

I would say in principle yes you can use CO_2. In addition to Mr. Cariven's remarks, I would like to point out that the density of CO_2 is a disadvantage. CO_2 is heavier than air while nitrogen has almost the same density as air. CO_2 may not follow the ventilating air because of the density difference.

But we have used CO_2 especially in a shaft situation. We had a gas ignition in the bottom of a very old shaft which was cleared. We used CO_2 and it worked very well. I had a discussion with a colleague from the States a few weeks ago. He is using CO_2 as a fire fighting technique against spontaneous combustion and it works.

You should also bear in mind that it is more difficult to monitor the fire situation if you use CO_2 instead of nitrogen. It is possible that the CO content may rise if you use CO_2.

Comment by Mr. A.R. MacLean

In 1975 we had a fire in No. 26 Colliery, and we weren't getting it out very well. That seam sloped at about 15 or 17 percent. We started to look at the question of nitrogen and CO_2. Nitrogen wasn't available to us, but CO_2 was. In fact, we got CO_2 from Sarnia, we took in tank cars of CO_2. I think there was 230 tons of liquid CO_2. We drove that into the pit yard, got a heat exchanger made and hooked into one of our water lines. The fire was about five miles away from the surface. Just with the heat exchanger on the surface, hooked to the rail cars, we pumped the stuff into the fire area and put out the fire. I agree that nitrogen, in all likelyhood is much better. I have no quarrel with that at all. I think CO_2 can mask what is going on in a fire, but the fact remains that it works. If I had to do it, I would do it again.

POLISH EXPERIENCE IN POST EXPLOSION ACTION AND INVESTIGATION

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1. INTRODUCTION

The Polish coal mining industry, with its yearly output oscillating around 200 million tons of hard coal, has to devote much attention to the problem of combating mine hazards. In all the three hard coal basins: The Upper Silesian, the Lower Silesian and the newly developed Lublin Coal Basin, typical mine hazards occur, with different intensity. Methane hazard is present in all basins. More than half of the hard coal output is won from gassy seams.

In the Upper Silesian Coal Basin great rock burst hazard as well as fire danger exist. The majority of the occurring coals are namely prone to self-combustion.

The gas outburst hazard is typical for the Lower Silesian Coal Basin.

In the new Lublin Coal Basin, where the first output tonnage is to be won still this year, there are great water hazards which largely contributed to the delay in mine construction in this area.

Nearly in all mines highly explosive coal dust occurs.

In order to attain safe working conditions, in mines an adequate prophylaxis is carried out to control those hazards, and in case the hazard manifests itself in the form of an accident or disaster, activities are also organised for limiting the effects. Special services are trained for undertaking effective post-disaster actions, the chief aim of which it is to limit the accident results, above all to rescue men.

The present paper describes the main organizational outlines of those services and the way of conducting post-disaster actions.

The whole matter will be presented from the point of view of an research institute dealing with safety-in-mines problems.

Mine science plays an important part during conducting post-disaster actions. As it will be shown in more detail in the further part of the paper, scientific workers are - on the one hand - advisers putting their knowledge and experience at the disposal of the management of the action and - on the other hand - each post-disaster action is a source of invaluable information which inspires new investigations. In post-disaster actions also a severe verification of the scientific research work takes place. Thus there are mutual benefits.

Owing to the author's specialization, the main stress will be laid on post-explosion actions. This will be illustrated by several selected examples of actions in which the author participated personally. The scope of the paper does not allow for an extension of the subject area. Should the participants show interest in other subjects connected with the Symposium, the author is ready to expand the subject area during the presentation of the paper at the Symposium.

2. ORGANIZATION OF RESCUE ACTION IN A MINE

2.1 DEFINITION OF A RESCUE ACTION

In accordance with the Polish Regulations such activities are regarded to be an rescue action that are connected with bringing help in case the lives or health of men in the mine are endangered and also in case the safety of the mine is endangered by:

- underground fire
- gas explosion
- coal dust explosion
- gas outburst or emission of gases into the mine workings rendering the atmosphere unfit for breathing
- sudden inrush of water, slurry or loose rocks into the underground workings
- rock burst or cave-in
- break down of technical equipment.

We distinguish difficult and easy actions.

An action is regarded to be difficult to carry out when:

- men are rescued
- explosive concentrations of combustible gases occur
- open fire is liquidated
- the dry thermometer temperature at the rescue place is higher than $40^{o}C$
- CO concentration in the mine air surpasses 20 ppm
- CO_2 concentration in the mine air is 6% or more
- rescue work is done at the liquidation of caved waste
- rescue work is done in shafts, blind shafts and steep workings
- work is done under water
- rescue work is performed by the men wearing oxygen breathing apparatus.

2.2 PREPARATION OF A MINE FOR PERFORMING RESCUE ACTION

According to Regulations, all the personnel, material, technical and organizational means, prepared at the mine, that are indispensable for a quick and efficient performance of the rescue action in case of a mine fire, explosion or caving-in, are comprised in the:

- colliery fire-fighting action plan
- mine rescue and first aid plan for the case of a mine fire, explosion of gas or coal dust, cave-in or inrush of water occurring.

The colliery fire-fighting action plan contains:

A. Data on:

- depression and capacity of the main fans
- arrangement of the fire fighting equipment on the colliery surface and underground.
- localization of the emergency stores of the mine itself and of the divisional coal board
- places where fires are likely to occur

B. Schemes and ventilation and mine maps containing the layout of pipelines for fire fighting, stowing, compressed air and degasification, electrical equipment, communication and alarm devices and of the monitoring apparatus.

C. Directives concerning the sequence of men withdrawal from the hazardous zones.

D. Instructions on the organization of the fire-fighting action at the mine.

E. Instructions for the mine supervising personnel describing the mode of conduct from the moment of fire detection till receiving the first directives from the leader of the rescue action.

F. List of responsibilities of the members of the mine management and the mine supervising personnel in case of conducting fire-fighting actions.

G. Guidelines for the mine supervising personnel concerning the training of the underground crew how to behave in case of a mine fire.

H. Ready documentation, blank forms, indispensable for entering all kinds of records during the rescue action.

The mine fire-fighting plan, together with the mine operation plan, is approved by the District Mining Authority (DMA).

The mine rescue and first-aid plan contains:

A. the mobilization plan of institutions and persons together with the plan of organizing the alarming system.

B. specification of the responsibilities of individual persons at the mine during a rescue action

C. data on:
   - mine rescue organization at the mine
   - organization of the readiness of management, supervising personnel and rescue workers at the mine
   - organization of the mine gas-analysis laboratory
   - organization of the sanitary and medical service at the mine

D. plan of mutual back-up help of mines during actions

E. enumeration of specialized institutions, rendering e.g. emergency service in the field of transportable emergency hoists, drilling, that are foreseen to do rescue work in mines

F. list of institutions foreseen to give additional assistance during large-scale rescue actions, militia, army, fire-brigade

G. list of technical means present at the mine and the basic outfit of stores with hazard combating equipment,

H. instructions and guidelines for conducting rescue actions

I. provisions regarding the actualization, storing and approval of the plan.

All members of the mine management and the supervising personnel are obliged to get acquainted with the mine rescue and first-aid plan. This concerns in particular persons responsible for performing and supervising definite operations during a rescue action.

2.3 ORGANIZATION OF THE MANAGEMENT OF A RESCUE ACTION

The Polish Mining Regulations determine the composition of the mine rescue action management. It is as follows:

- leader of the rescue action
- leader of the rescue action underground
- manager of the rescue basis.

The Regulations state also who can perform the above functions.

As time plays an important role in rescue actions, in the initial phase of the action these functions can be exerted by substitutional persons. Those can be: on the surface - members of the mine management or mine supervising personnel present at the mine and the mine dispatcher, the underground - each member of the mine management or mine supervising personnel who is nearest the hazardous region.

As a rule, the mine manager is the leader of the rescue action. Because the supervision of the rescue action rests with the Mining Authorities, in case the action is conducted improperly, they can demand the change of the leader or take over the management of the action themselves.

The leader of the rescue action occupies a separate room which can be entered only by persons appointed by him. After taking over the leadership of the action and getting acquainted with the actual situation, the rescue action leader is obliged to:

- determine the hazard zone and the state of danger to which the mine crew in this zone is exposed;
- appoint the place for the rescue basis;
- continue the withdrawal of the endangered people;
- establish the ventilation conditions of the hazardous zone,
- above all to prevent the occurrence of hazards due to methane, noxious gases or oxygen deficiency;
- establish the way of removing the results of the hazard;
- establish the personnel roster of the management of the rescue action and appoint men from among the supervising personnel for carrying out rescue work at the individual shifts or to perform specific tasks;
- establish the number of the necessary rescue teams.

The leader of the rescue action is obliged to give a notification to his superiors and to the Mining Authorities once a shift.

The organizational scheme of the rescue action management is shown in Fig. 1.

The organization system is divided into three divisions:

- the division which realizes the rescue work, i.e. the division which is responsible for performing rescue work underground according to the orders of the rescue action leader;

- the safeguarding division, i.e., the division which is responsible for the performance of basic work on the surface and auxiliary work underground;
- advisory division.

The role of the last division will be discussed in more detail owing to the person of the author who has taken part in rescue actions in the capacity of a member of the advisory staff and also because the Central Mining Institute, which he represents, ex officio belongs to the rescue action staff, as settled by pertinent provisions.

The staff is an advisory body of the rescue action leader.

The rescue action staff comprises representatives of the Ministry of Mining and Power, Mining Authorities, the Central Mine Rescue Station, specialists from the Central Mining Institute, research workers from mining high schools, the ventilation officer of the mine and possibly specialists from other mines. When there are great actions, e.g. during mine disasters, also a spokesman of the press is appointed. The advisory staff is headed by a representative of the ministry or a person appointed by the rescue action leader in agreement with representative of the ministry.

The room of the rescue action staff is in the neighbourhood of the rescue action leader. In order to provide the staff immediately with information on the course of action, a communication system is installed in that room making it possible to hear the conversations of the rescue action leader.

The basic tasks of the staff comprise the analysis of the situation underground, mutual settling of proposals concerning the way in which to perform the rescue work as well as ensuring the safety of that work. The proposals are given in writing to the rescue action leader by the chief of the advisory staff. The staff members cannot directly interfere with the activities of the action leader by suggesting their own advice. At the same time, by following the advice and recommendations of the staff, the action leader does not get rid of his responsibility since it results from the principle of one-man management.

In addition to the above mentioned activities, the representives of the Safety-in-Mines Institute, the Barbara Experimental Mine - which is part of the Central Mining Institute - accomplish a number of other tasks. They:

- collect information which is later used during working out the official report on the causes of the accident - methane fire gases or coal dust explosions or gas and rock outbursts;

- give advice in the field of safe rescue action performance, in particular what regards protection against explosions;
- fix the proper moment for sending a team underground to do post-accident investigations;
- give specialistic assistance, with regard to gas analysis, calculation of explosibility factors and so on, to the men directing the action.

During the action an important part is played by the technical secretary to whose responsibilities it belongs:

- to enter, on behalf of the rescue action leader, all commands given and all notifications received into the "rescue action book";
- to complete documentation needed by the rescue action management;
- to complete maps indispensable for conducting the action;
- to set up collective gas analysis reports
- to operate the communication equipment.

In rescue actions the fundamental role is played by the professional rescue service. Knowing the organization of that service one can get an insight into its responsibilities during rescue actions. Data on the organization of the mine rescue service in Poland are given in the next paragraph.

3. MINE RESCUE ORGANIZATION IN POLAND

The basic aims of mine rescue are:

- to maintain in constant readiness personnel, technical and organizational technical means so as to be able to bring immediate help if the lives or the health of the mine crew are endangered or if serious danger threatens the safety of colliery operation;
- to popularize among the miners the principles of preventing and combating hazards occurring in underground mine workings and to equip the miners with proper means protecting them against the consequences of hazards;
- to do work at mines preventing or limiting the range of the hazard.

The above mentioned aims are realized by the Polish mine rescue service through a three level organization system.

The organizational unit which directs the whole work of mine rescue on the terrain of Poland is the Central Mine Rescue Station (CMRS) at Bytom. This Station supervises and controls mine rescue in all Polish mines, extracting coal and other useful minerals. It is subject to the Ministry of Mining and Power.

The second organizational level constitute the District Mine Rescue Stations (DMRS), which supervise the state of mine rescue at mines. In Poland there are 12 District Mine Rescue Stations.

During rescue actions the District Stations help not only mines of their own district. In such a station there is always an emergency rescue team ready for action. It consists of rescue men delegated in turn from each mine for the time of two weeks. The emergency team consists of 13 men: 11 rescue men, one mechanic and a leader of rescue team.

In the District Mine Rescue Station equipment is stored for:

- detecting and controlling gases;
- respiratory protection of rescue men;
- telephone and radio communication for rescue purposes;
- giving medical help;
- extinguishing and isolating fires;
- performing rescue operations in case of cave-ins;
- removing water when underground workings are flooded;
- salvaging people by the help of the drilling technique.

At the District Mine Rescue Station at Bytom, not to confuse with the Central Mine Rescue Station, a professional emergency team acts which consists of 56 rescue workers.

The training and routine exercises are done at the District Mine Rescue Stations and at the Central Mine Rescue Station.

The third mine rescue level is the rescue service of the mines. It consists of the mine rescue teams and the mine rescue stations. The minimum number of rescue workers in the rescue team is:

- 15 men in mines employing less than 500 persons underground per day;
- 30 men in mines employing more than 500 persons underground per day.

A rescue worker must fulfill certain conditions.

Each mine rescue station employs permanently some mechanics. Rescue teams have the following specializations in:

- working in shafts
- driving rescue galleries
- extinguishing fires in gassy mines
- performing drilling operations
- sealing stoppings and workings
- performing work under water
- constructing explosion proof bulkheads
- rescue communication
- hydraulic stowing
- servicing energo-mechanical equipment
- fire fighting
- operating powered supports
- removing consequences of gas outbursts.

At a Mine Rescue Station there should be the following number of breathing apparatus:

When the man power is:

- 500 men	- 12 apparatus
- 501 - 1000 men	- 18 apparatus
- 1001 - 3000 men	- 24 apparatus
- over 3000 men	- 30 apparatus

In hard coal mining the following specialized emergency services are in existence:

- the transportable emergency hoist service for saving people in case of a shaft break-down;
- the drilling service for saving people through boreholes;
- the service for operating inert gas generators.

The transportable emergency hoists service is localized in enterprises possessing hoists suitable for this purpose. Those are hoists of the Hyse 1.25 type produced in Sweden and the Polish-made B1500A hoists which during shaft breakdown make it possible to get people out of shafts from depths of up to 1000 m.

The drilling service is provided by enterprises of the oil and gas extracting industries, by enterprises doing development work at mines and by the Methane Drainage Enterprise. The above mentioned enterprises dispose of equipment for drilling small diameter boreholes from the surface and from underground workings as well as of equipment for drilling large-diameter boreholes between levels, from the lower to the upper one TURMAG drilling machines of the EW-1200 type.

This service includes also equipment for saving people through boreholes, this equipment being stored in the Central Mine Rescue Station.

The service for operating inert gas generators is composed of transportation enterprises which give facilities for transporting the inert gas generators (Polish abbreviation GAG) and other fire-fighting equipment.

4. ACTIVITIES OF THE SAFETY-IN-MINES INSTITUTE, BARBARA EXPERIMENTAL MINE IN THE FIELD OF POST-DISASTER ACTIONS.

Employees of the Barbara Experimental Mine have carried out post-disaster investigations after each mine explosion, independent of its scope, strength and consequences, for more than 50 years. Those investigations are aimed at reproducing the course of the explosion and the circumstances which have lead to the initiation of the explosion. In order to be able to fulfill its tasks in this field efficiently, the Barbara Experimental Mine is properly organized and equipped.

4.1 ORGANIZATION

Employees of the Experimental Mine who have great experience in the specific fields, are - by turns - on round-the-clock duties at home; the dispatcher of the Ministry of Mining and Power is notified about the duties every week. In case an accident or disaster takes place, the persons on duty are obliged to notify the director of the Barbara Experimental Mine, or his deputy, who organizes the departure to the disaster.

Also, one of the drivers is on home duty, or the place where he stays is known. A place has been fixed where the equipment needed for investigations is always kept.

4.2 EQUIPMENT

A. For performing investigations at mines, at the Barbara Experimental Mine the following equipment is kept at a fixed place:

- water sampling tubes	30 tubes
- hermetically sealed containers for coal samples	5 pieces
- portable methanometers	5 pieces
- explosimeter	1 piece
- detector with indicating tubes	1 piece
- gauges for gas measurement in boreholes	2 sets

- box with instrumentation for taking dust and coke samples
- anemometer 2 pieces
- velometer 1 piece
- electrical multimeter 2 pieces
- photographic camera with flash lamp and tripod
- instrument for measuring stray currents, of the MPB-5 type.

B. For carrying out investigations on the samples, means, and devices taken from the disaster-stricken colliery, all the laboratories of the Barbara Experimental Mine are at disposal and in case of need they work round the clock.

Should need arise then highly experienced employees - above all the director of the Safety in Mines Institute, Barbara Experimental Mine - are on duty on the advisory staff at the accident mine.

4.3 POST-EXPLOSION INVESTIGATIONS

The post-explosion investigations are carried out directly at the mine in which the accident has taken place and in the laboratories of the Barbara Experimental Mine.

Investigations done at the mine comprise:

- a thorough and detailed observation of all accessible workings affected by the explosion and of the neighbouring workings. Recorded are traces of the effect of high temperature as well as the direction in which the barrier and the outfit of the mine working have been thrown, due to the action of the shock wave, the displacement of supports and heavy equipment and so on;
- taking air samples and determining the contents of CH_4 and CO;
- taking coal samples in order to determine the content of gas in the coal;
- taking dust samples for determining the magnitude of dustiness, the incombustibles and moisture contents in the dust and the flame range;

- analysis of the state of the barriers and of the dustiness combating equipment;
- ventilation measurements;
- description of the state of the electrical equipment and devices;
- characteristic of the applied blasting accessories and kind of explosives used;
- taking pictures of the most characteristic post-disaster spots.

Investigations done at the Barbara Experimental Mine, and in particular in its laboratories, comprise:

- analyses of the taken air samples;
- designation of the content of combustible gases in coal;
- designation of the chemical and physical quality of the dust samples;
- microscopic evaluation of coke content in dust samples;
- qualitative analysis of the used explosives;
- expertise of the blasting accessories and the electrical equipment;
- analysis of witness-hearing protocols and of photographs.

In some cases, which were especially difficult to be explained, in the experimental galleries investigations simulating the gas and coal dust explosions were done.

4.4 POST-DISASTER INVESTIGATION RESULTS

The Results of Post-Disaster Investigations contain the following chapters:

- Introduction, characterizing the place and the consequences of the disaster;
- Techno-mining and ventilation characteristic of the disaster section;
- Methane hazard investigations of the seam and the disaster-stricken workings;
- Coal-dust hazard investigations of the disaster-stricken workings;
- Determination of the explosion flame range;
- Characteristic of the state of electrical equipment in the workings after the explosion;

- Investigations of the blasting accessories;
- Additional investigations connected with the explosions, such as: photographic documentation, combustibility trials of e.g. cables, testing lamps, accumulators and so on.
- Expert evidence on the causes and circumstances of the explosion.
- Conclusions.

5. COMMISSION FOR INVESTIGATING THE CAUSES AND CIRCUMSTANCES OF THE DISASTER.

Still during conducting the post-disaster action, the Chairman of the Higher Mining Authority HMA in consultation with the Minister of the proper ministry, to which the disaster mine is subject, appoints the Commission mentioned in the title. The Commission is composed mainly of persons who are on the advisory staff of the post-disaster action. The Commission is chaired by one of the Vice-Chairman of the Higher Mining Authority, who also participated in the work of the advisory staff. The Commission is made up of the following persons:

- director of the mining department of the ministry;
- director of the District Mining Authority;
- director of the Central Mine Rescue Station;
- representative of the CMI - Safety in Mines Institute, Barbara Experimental Mine; usually the Director or his deputy;
- director of the superior authority of the disaster mine;
- the proper specialists e.g. from universities.

The members of the Commission get acquainted with the causes and circumstances of the disaster already during the post-disaster action. During its subsequent meetings the Commission prepares a report. This report is based chiefly on the inspection of the disaster place, the results of the catastrophic event, course and evaluation of the rescue action, investigations of the District Mining Authority under the supervision of the Higher Mining Authority, results of investigations done by the Barbara Experimental Mine and its experts, evidence and possibly additional specialistic expertises prepared by competent institutions or experts.

For example, the report made after a catastrophic explosion includes the following chapters:

A. Introduction - contains information on the event and personal data of the victims;

B. General characteristic of the mine - contains data on the occurring hazards, applied preventive measures, previous events;

C. State of mining activities in the disaster area;

D. Description of the electro-mechanical equipment;

E. Circumstances and course of explosion;

F. Course and evaluation of the rescue action;

G. Results of investigations conducted in connection with the explosion;

H. Causes of the explosion and the group accident;

I. Conclusions of the Commission concerning the:

- mine in which the disaster took place;
- all hard coal mines;
- scientific research centres;
- regulations, instructions and directives being valid at the present moment.

The Report is the basis for undertaking legal procedure against persons guilty of the disaster and is also the basis of various actions at different management levels aimed at evading similar disasters. Among other things it promotes the improvement of rescue actions.

6. EXAMPLES OF RESCUE ACTIONS

EXAMPLE 1

During methane explosions hazards often overlap. Thus, a methane explosion can be the cause of further hazards, such as coal-dust explosions, the formation of cave-ins and of fires. An example of a rescue action conducted due to the coming into being of such a complex of hazards is the action commenced at the "Silesia" hard coal mine on July 28, 1974 in result of a methane explosion combined with a coal-dust explosion (Fig. 2). At the time of the explosion, in the section of the longwall No. 69 was in operation and the longwall No. 62 was being prepared. Already a longwall raise was ready for longwall No. 62. Besides, two galleries were being driven, namely the return airway on Level O and the intermediate road. The longwall No. 69 had a length of 108 m and a height of 2.5 m. It was supported by segmentary steel roof-bars and hydraulic props fed from a central pump.

Coal was worked by explosives, use being made of cutting machines.

During the transportation of material via the transport incline it was necessary to open the ventilation door of the air stopping installed in that incline. This caused ventilation disturbances in the region of the longwall No. 69, the amount of air sweeping the longwall decreased, and the CH_4 concentration rose. The concentration was measured by the recording methanometer of the Barbara ROW-3a type, which was installed in the return airway at longwall No. 69.

An increase of CH_4 concentration was also recorded when after a longer standstill, lasting for some tens of hours, the auxiliary fan was put into operation in the top heading I.

A growth of methane concentration was noted on June 28, 1974, from 9.30 to 10.29, when the concentration surpassed the measuring range (2.5% CH_4) of the methanometer. This state lasted for 16 minutes up to 10.36, when the explosion took place. This state was signalled optically and acoustically in the dispatcher room, but the dispatcher on duty did not react to these signals.

The explosion affected the following workings; the return airway on level O, longwall No. 69, the top heading II, the raise of the being prepared longwall No. 62 and the top heading I. The explosion was stopped by the operation of stone-dust barriers installed in the return airway on Level O, the top headings I and II in the neighbourhood of the transport incline. During the explosion, there were 86 men in the hazardous area. Out of these 34 men found their death due to the effect of the explosion flame, high temperature and strong shock wave in workings having a length of 1 km and were killed by noxious components of post-explosion gases on the way of their flow. The explosion caused cave-ins at the crossings of the raise of the being prepared longwall No. 62 in the distributing headings I and II, rock fall-down at the crossings of the longwall No. 69 with the bottom road, destruction of air stoppings.

The dispatcher was informed about the occurrence of the explosion at about 10.45 by the section foreman who had been in the neighbourhood of the loading point of the section in the main heading on Level I.

The crew withdrew from the explosion region using filter self-rescuers of the POG-type.

The first rescue teams were directed to:

- workings through which the post-explosion gases drew out, this is to the longwall top airway on level O, to the ventilation drift on Level O and further till shaft No. V;
- workings, in which, on the basis of initial recognition, it was expected to find the greatest number of victims, namely to longwall No. 69, top heading II and transport incline.

Among the 29 persons who were found by the rescue men in those workings there were no mortal victims. They were transported through the rescue basis to the first aid station of the mine and next to hospitals in the neighbourhood.

The greatest number of mortal victims were encountered in the top heading II and in the longwall No. 69.

Thanks to the quick restoration of proper ventilation the region was cleared from noxious gases and physicians could enter the direct explosion area. Because the explosion had catastrophic results, and in particular caused a great number of victims, the action was conducted on a large scale. For example 30 normal ambulances and 2 reanimation ambulances were brought to the colliery. 42 physicians were ready to take care of the victims. At 14.15 the penetration of the workings in search of victims and work connected with giving medical help to the living victims was finished.

Then, successively, the corpses of the dead were brought to the surface and the recognition of the causes of the explosion was commenced. A commission was created to settle the causes of the explosion. The commission went down to the disaster area. In addition to this, two teams of specialists were organised for an exact inspection of the workings affected by the explosion. During the inspection, at 0.30 on June 29th, in the bottom road of longwall No. 69, an open fire was noticed. Immediately all persons, but the rescue men, were ordered to leave the hazardous area. Again, rescue men from the emergency service of the District Mine Rescue Station were called into action and the fire-fighting action commenced.

The fire greatly complicated the situation underground. Till the fire was noticed, it had not been possible to state the exact cause of the methane accumulation and explosion initiation, basing on details collected so far.

Because of great hazard threatening, the decision was taken to liquidate the fire by means of stoppings. Finally, it was decided to provide explosion-proof gypsium bulk-heads and to neutralize the atmosphere behind the bulk-heads by inert gases.

For the first time in the history of the Polish coal mining, the inert gas generator was used which produces an inert steam gas mixture. The generator of the GIG-4 type was brought from the Soviet Union, together with a team of specialists. The fire-fighting action was finally finished on July 6, 1974.

THE REASONS OF THE OCCURRENCE OF THE HAZARD

Prior to commencing the fire-fighting action it had been possible to state that the accumulation of methane in the explosive range, in the air coming to longwall No. 69, was the result mainly of starting the auxiliary fan, which ventilated the top heading I. The methane explosion was probably initiated in the upper part of the longwall No. 69. The initiation was brought about by frictional sparks produced by the picks of a cutting machine coming in contact with the stone substatum of the floor or by electrical equipment installed in the face.

The possibility was excluded that there was an interrelation between the fire and the selfheating which had been stated and was being removed before the explosion occurred. The appearing of open fire after the men-saving action was connected with the interruption of water infusion to the place where the self-heating occurred and the destruction of the air stoppings due to the explosion.

EXAMPLE 2

Another example of the origin of a complex hazard is the methane and coal dust explosion in the Anna hard coal mine on November 7, 1974.

The explosion took place at 5.00 in the region of section G VII, in seam 630, in the Jedlowice part. It was initiated in workings affected by the rock burst which had taken place in the region earlier, namely at 3.24.

In the Jedlowice part, between the 500 m and the 700 m levels, in its western wing, seam 630 is counted to the II methane danger category. Coal is won there by the longwall system with caving with faces on level. On the day when the rock burst and the explosion occurred, in the G VII section only longwall No. J-2 was in operation and for longwall No. J-4 development work was going on. As there was a 12-14 m thick layer of sandy shale in the roof, the longwall was operated under special conditions. The longwall had a length of 160 m and its thickness varied from 1.5 to 2.6 m. The dip was 15-19°.

COURSE OF THE ROCK BURST AND RESCUE ACTION

At 3.34 in the workings of section G VII a strong shock occurred, accompanied by air blast and crash. Those phenomena, which are characteristic for a rock burst, were felt in the whole section. The shock was recorded on the surface by seismographic stations, inter alia those in Raciborz, Dabrowa Gornicza and Cracow.

The rock burst caused:

- a total or partial caving of the return air incline along a 320 m long section beneath the 500 m level, of five cross-cuts, between the return air and the belt inclines, having a total length of 125 m and of the transport incline on a length of 265 m;
- damage of supports in the longwall raise J-4, west, from the side of the bottom road J-2 on a length of 24 m;

- crushing of non-mined pillars between the return air incline and the transport incline and the cross-cuts connecting both inclines;
- damage of the 6KV and 500 V cables and of the communication system with the 500 m level, installed in the return air incline. In result of this the whole 500 m level was deprived of energy supply.

The rock burst and the damages resulting from cave-ins caused the stoppage of the fan ventilating the being driven incline J-6. Besides, the main way for transporting fresh air to section G VII was interrupted due to the caving of the return air incline.

In the rock burst area three men were injured, two seriously and one slightly, by objects tipped over by the air blast and by the impact of rock fragments and support elements. The men were in the return air incline, the gallery J-2 and the gallery J-4. The remaining crew suffered no harm.

After men from other sections of the mine had notified the dispatcher about the rock burst, the undertaken rescue action was confined at first to the withdrawal of the whole crew from the hazardous area.

COURSE OF EXPLOSION AND CONTINUATION OF THE RESCUE ACTION

At about 5.00 miners and supervising personnel, who were already at the underground railway stations on the 700 m level, as well as men engaged in removing debris from the faulted part of longwall J-5 in seam 630 and section G VI, and maintaining haulage equipment, again felt a strong shock and a violent air blast. In addition to this, workings in the neighbourhood of the underground railway stations became strongly dusted by stone dust originating from stone-dust barriers and dusted zones. The rescue action management was notified about those facts. At first they thought that these phenomena are connected with a secondary rock burst. Yet a detailed recognition which was made showed that this phenomenon was a methane - coal dust explosion.

The explosion was no immediate threat to the people, because in the region where it occurred there were no men, as they managed to withdraw earlier. Also in the remaining regions there were no men since the working shift ended at 5.00.

The colliery rescue teams called to action and the emergency teams from the District Mine Rescue Station penetrated the accessible workings of the region affected by the explosion. During the penetration it was stated that the range of the explosion had covered workings of section G VII in seam 630 damaging the supports, causing fall of ground and cave-ins and damaging mining equipment in longwall J-2, bottom road J-2, top road J-2, return air incline leading to the 500 m level, longwall raise J-4, longwall raise J-2, east, incline J-6, bottom road J-4 and in the cross cut linking the main road in seam 630 with the bottom road J-4. The total length of the workings through which the explosion flame passed was about 1940 m. The explosion was stopped and confined in result

of the effective operation of stone-dust barriers.

The removal of the consequences of the explosion took two weeks and was done by rescue teams and the crew of the colliery. During the removal of the effects of the cave-in, periodical methane accumulations were stated in the return air incline up to 4.15% and in the bottom road J-4 up to 6%.

Basing on symptoms stated in the workings affected by the explosion it was assumed that the progress of the explosion was as follows:

- first a local methane explosion took place within the caved return air incline, the place of initiation was not determined exactly;
- the local methane explosion initiated the coal-dust explosion, the dust being generated during the rock burst.

The accumulation of methane within the return air incline was due to intensified emission of CH_4 during the rock burst. This was the first case in the Polish coalmining industry that a rock burst was accompanied by increased CH_4 emission.

The following factors were assumed as the most probable ignition source:

- damage of the high voltage cable during the short-circuit caused by the cave-in;
- transmission of signals via the damaged telephone cable in the time between the rock burst and the explosion. The telephone network was not intrinsically safe.

It also cannot be excluded that voltage was again connected to the power network installed in the rock burst region.

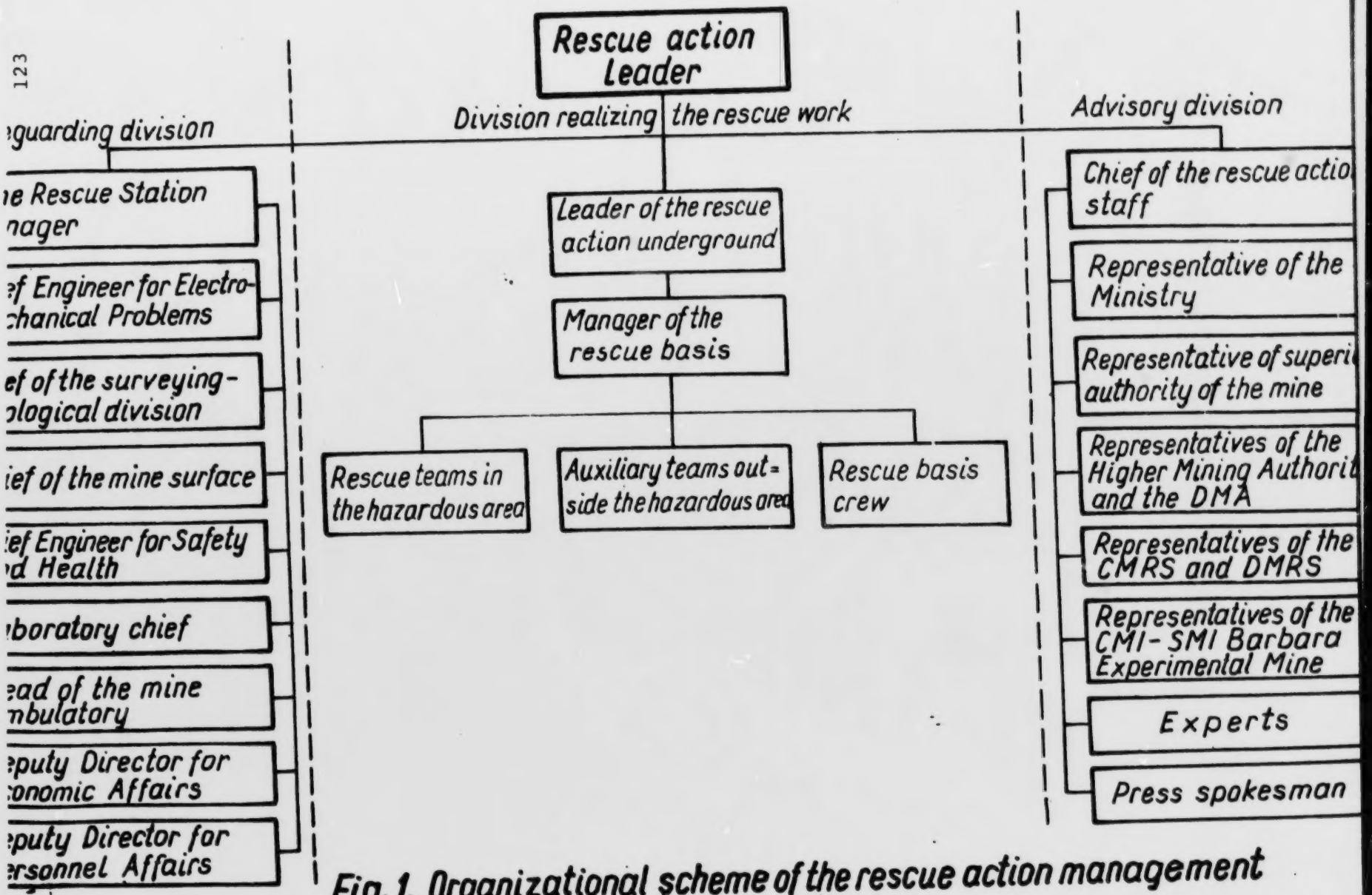
Rescue action Leader
guarding division
Division realizing the rescue work
Advisory division
ne Rescue Station nager
ef Engineer for Electro- chanical Problems
ef of the surveying- ological division
ief of the mine surface
ief Engineer for Safety d Health
boratory chief
ead of the mine mbulatory
eputy Director for conomic Affairs
eputy Director for ersonnel Affairs
Leader of the rescue action underground
Manager of the rescue basis
Rescue teams in the hazardous area
Auxiliary teams out- side the hazardous area
Rescue basis crew
Chief of the rescue actio staff
Representative of the Ministry
Representative of superi authority of the mine
Representatives of the Higher Mining Authorit and the DMA
Representatives of the CMRS and DMRS
Representatives of the CMI- SMI Barbara Experimental Mine
Experts
Press spokesman

Fig. 1. Organizational scheme of the rescue action management

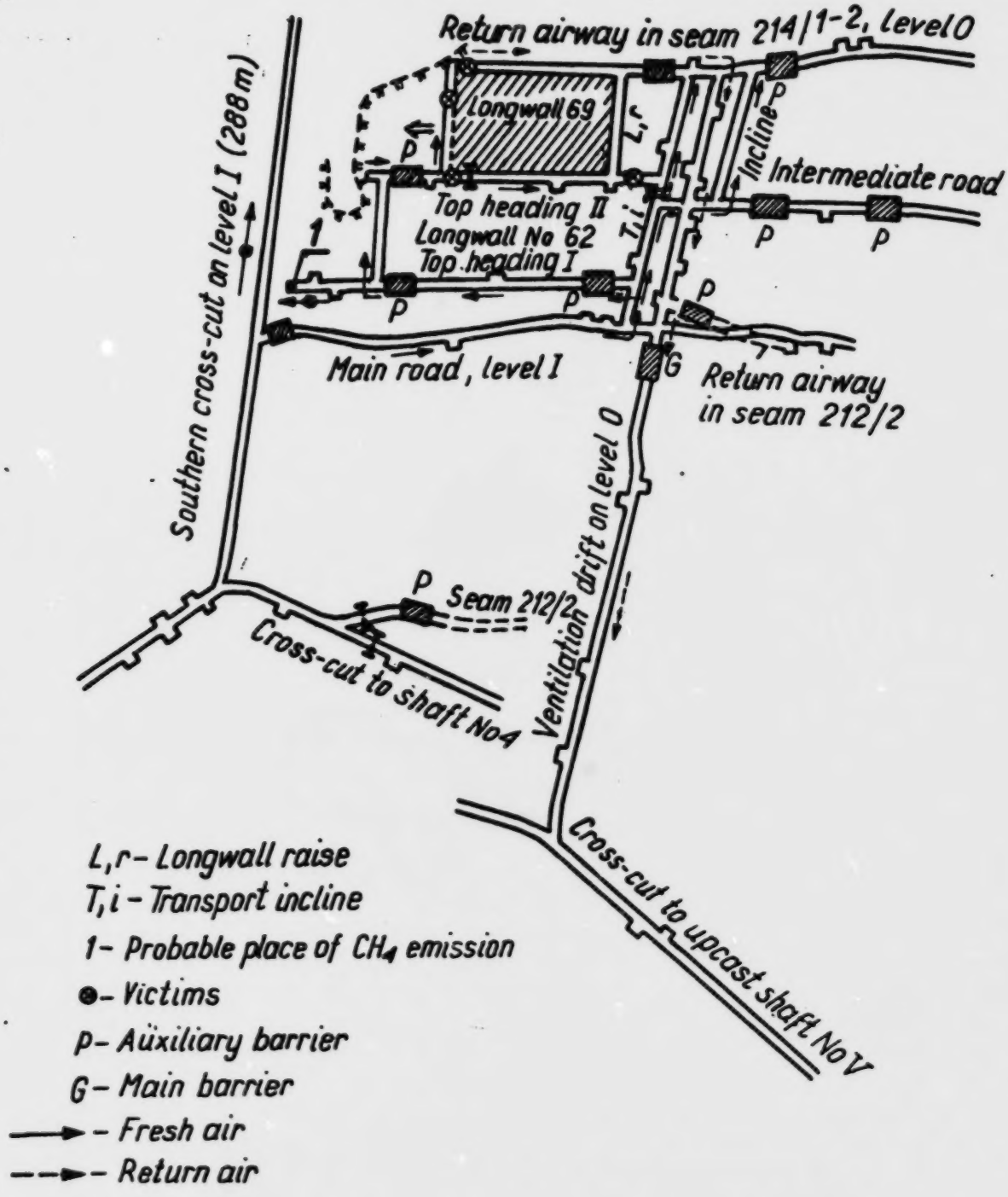

Fig. 2. Disaster area in Silesia colliery (1974)

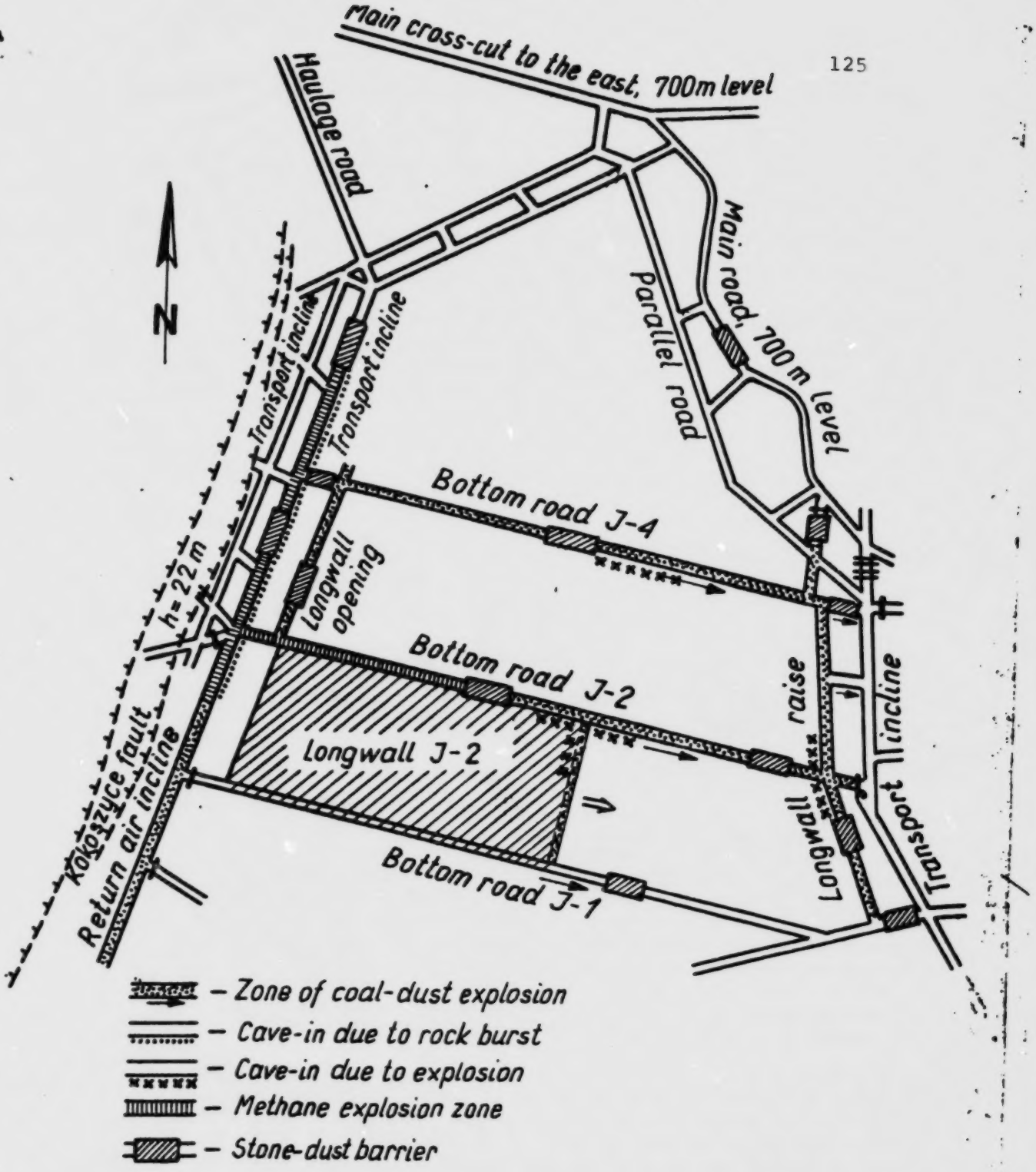

Fig. 3. Disaster area in Anna colliery (1974)

DISCUSSION FOLLOWING PRESENTATION OF DR. P.A. KRZYSTOLIK

Q. Mr. Kock, West Germany.
In Poland, are these rules so that you can start your investigation during the rescue action?

A. There are no rules and normally, we are involved with the advisory staff. The advisory staff colaborate very closely with the leader of the rescue action and normally the investigation starts when the victims are removed from the disaster region. But in some cases, for instance where there is a potential mine fire, during the first steps of the mine investigation, two investigation teams are sent underground. But normally, we go underground after the victims are removed. But I think that the aim of the investigation is to have information on how to be prepared to prevent new accidents. From that point of view, I think that it is absolutely necessary for the investigation team to go underground as early as possible.

Comment by Mr. Bruce Stewart

I was in Poland about a year ago, and saw a demonstration of their inert gas generating system at the Central Mine Rescue Center, and I think it would be useful if you could, in a few minutes, summarize that inert gas generator, in particular the volumes of output that are possible, and the time between the notification of a disaster and the time you can have that machine installed and operating.

Dr. Krzystolik

I think yesterday there were some problems with what is better, nitrogen or the inert gas generator. This is the same problem as we have with the mine transportation system. Is it a diesel engine or a rail system? We developed this generator after very good experience in a Silesian mine. We developed our own with bigger output of inert gases. In fact, the generator is not only a CO_2 generator, but has value as a low oxygen generator. For instance, the unit has an output of about 1000 cubic meters per minute. The consentration in wet conditions is 31 percent of nitrogen, 5 percent of CO_2, .04 percent of oxygen, and 64 percent of water, as vapour.

In dry conditions, when the steam is removed in the workings, we have 85 percent of nitrogen, 14 percent of CO_2 and about 1 percent of oxygen. We also have a system that we use quite often, and that is the system of nitrogen. But most of our mines in which we have mine fires are old. The distances from

the shafts to the workings are also sometimes very large. We don't use a pipe line system for nitrogen, we use 650 kilo bottles with nitrogen. We go in the mine with the bottles and we create a local system of evaporating the nitrogen. With the inert gas generator, it is not a bulky system. We have about 50 kilometers from the mines to our central rescue station. In one afternoon they can transport this generator to the mine and assemble the generator very fast. I think that in 10 or 12 hours they use it to extinguish a fire. Also, the possibility of closing the area with explosion proof bulkheads. You only need to run the inert gas generator for a few minutes to bring the oxygen content down so low that no explosive mixture can form. But the problem normally is not with the transportation or fuel and such, but with the existence of water. That is a very, very important factor, because it should be about 1 cubic meter per minute. We have normally in all the mines a fire station water system. In one mine, we came underground with the generator and the pressure of the water was very good, but the volume of the water was bad. What happened is that in the mine they used the pipe line to transport cement and after they had not cleaned it properly and so we had problems. Afterwards, the inspectors of the mines paid more attention to the water pipes, especially in a potential fire area.

Comment by Mr. Bruce Stewart

I will add one thing. The inert gas generator is a jet engine with a spraying ring assembly on the exhaust. You get a terrific volume out of a small jet engine.

TOWARD A
"PLAN FOR SURVIVAL"
IN
HARD ROCK METAL MINES

BY

G. G. McPHAIL
RETIRED SENIOR MINE RESCUE OFFICER
PROVINCE OF ONTARIO

PLAN FOR SURVIVAL IN HARD ROCK METAL MINES

McINTYRE PORCUPINE GOLD MINE FIRE

At 1:56 a.m. on February 8, 1965, a light flashed on in the gate house of the McIntyre Porcupine Gold Mine at Timmins. This light signalled the greatest change in Mine Rescue Training in Ontario since its inception in 1930. This light simply informed the gateman that an underground pump had failed to start, and that somewhere in the mine, water would soon be overflowing a sump.

A routine investigation was begun by the 12 to 8 shift supervisor, who, after checking the upper levels, descended No. 12 shaft. At the 4900 level he was carried into smoke, but without being able to stop the cage, continued to shaft bottom, emerging from the smoke at 5900 feet.

The long drawn-out search for the fire was begun by crews wearing McCaa 2-hour breathing apparatus.

Investigation later showed that the location of this fire was in just about the worst place possible, 6500 feet below surface and 5200 feet from the main shaft, over two miles away. Carbon Monoxide was present in the surface shaft house, necessitating the 4 mile round trip, for at least the first three days, being performed under oxygen in McCaa apparatus.

It soon became apparent that an advanced fresh air base must be established underground. The decision was reached to seal off all levels leading East from #12 shaft (some 20 in all) and to re-direct the fresh air up 12 shaft, out along 3875 level and up the main shaft to surface.

Hoistmen operated the #12 shaft hoist, wearing Demand Air Breathing apparatus. Using special adaptors it was possible in smoke to first re-charge their back cylinders and then breathe directly from large (300 cu. ft.) air cylinders. These cylinders are maintained by most Ontario mines at winze hoistrooms for just this purpose. This sealing operation required about 48 hours.

A crew had been sent along 6575 level to attempt to reach #15 shaft. On the way they discovered what appeared to be the cause and origin of the fire. A short stope gangway had collapsed onto the cable carrying power to 15 shaft. This collapsed timber, apparently ignited by the damaged cable, was burning and the backfill above it had partly filled the roadway.

A small high expansion foam generator had been brought in by plane and taken underground. This machine was set up and in seven minutes, filled the 6575 drift and extinguished the fire in the burning timber. Crews going through the foam later were able to establish that the fire had gone above 6575 level, and it had not started at the cave-in. The fire had come from the direction of 15 shaft through 650 feet of untimbered drift.

Surface fans which had been kept running, to prevent the fire from backing up into 15 shaft were immediately turned off.

Subsequent investigation disclosed the 15 shaft hoistroom burned out and the shaft gutted. The true cause and origin of the fire was now certain. On day shift Saturday, February 8th, a work crew had been erecting steel at the 6800 level station of 15 shaft. Despite precautions followed during burning operations and afterwards, sparks or slag must have ignited timber lower in the shaft and gone unnoticed.

Meanwhile, crews on 6100 were attempting to locate the top of the fire. They were driven back by intense heat, unable to reach the top of 10 raise which was felt to be the control point the fire would have to pass to go farther above. The fire was eventually controlled on the 5975 level.

The path of the fire extended 1190 feet vertically and 1755 feet horizontally through the workings. Temperatures in the ropeway and #15 hoistroom were sufficient to melt aluminum pipe but not copper wire. Babbitt in the hoist bearings melted and all electrical installations were charred. Through 650 feet of untimbered drift, ties and mud sills were totally burnt from beneath the rails without leaving a trace of charcoal or ash. The hoist drums originally written off as a total loss were found to be in better condition than before the fire. They were simply heat-treated or annealed by the 1500 degree temperature which decreased slowly as the shaft fire burned out.

Approved mine rescue methods for locating a mine fire underground and bringing it under control were followed. Eight teams were maintained on each 12-hour shift, with 16 teams over a 24-hour period.

Four hundred and five team hours or 2025 man hours were spent under oxygen. One hundred and thirty-five mine rescue men spent a total of over 9000 hours on stand-by and under apparatus from February 8th to 21st. 68 McCaa, 50 All Service Masks and 12 Scott Air Paks (for the winze hoistmen) were used.

No mine rescue team member was injured, no breathing apparatus failed on the job, no team member panicked nor lost his nerve, and no disciplinary measures of any kind were required.

CONVERSION TO BG 174

The major result of this fire was the decision of the Ontario Mining Association to request the Ontario Department of Mines to investigate some of the newer, longer-lived breathing apparatus on the market, with a view of replacing the McCaa apparatus. It was felt that while the McCaa had performed an excellent role in mine rescue work for 35 years, some of Ontario's mines had simply outgrown it. This was dramatically proved early in the McIntyre fire as a number of teams did not reach the fire before the reduction in their oxygen supply forced them to return to surface. This was not only a drastic waste of time, but allowed the fire time to get out of control again, and many McCaa cylinders reached dangerously low levels of pressure as the wearers reached surface.

This inability of rescue teams to reach the fire area and to apply any effective control measures early in the operation certainly prolonged the ordeal at McIntyre by many hours. This too necessitated many additional hazardous trips by rescue crews, who in trying to make even a little progress sometimes delayed their return trip beyond safe limits.

The main purpose of a 4-hour breathing apparatus is to provide a comfortable margin of safety for travelling, and still allow some time to produce effective results in rescue operations or in fire control in deep mines.

There is no intention, indeed it would not be permitted, to make use of the 4-hour life of this equipment solely to extend the period of actual work beyond present accepted limits.

An investigation was begun, first with the thought of moving to the use of liquid oxygen or liquid air. This type of equipment has the distinct advantage of producing cooler air for the wearer to breathe. For a number of years it had been used in the mines in central England where a source of liquid oxygen is close by.

Such is not the case in Ontario where our mining districts are separated by hundreds of miles with the industry extending 1,000 miles from one side to the other.

Reliable information was received from two of the major liquid oxygen manufacturers, that to date, no portable flask is available that will contain liquid oxygen for more than two days without gasification, with a subsequent build up of tremendous pressure (32,000 p.s.i.), unless vented to the atmosphere. This of course means a substantial loss of oxygen unless the gas is used up as it is produced. Another alternative method of storing the liquid is by maintaining the liquid temperature at -270 degrees F.

No individual mine rescue station in Ontario would consume in regular training more than a fraction of oxygen gas produced, and thus it was felt, from the cost standpoint, the use of liquid oxygen would be too expensive. A more important conclusion, however, was that the maintaining of sufficient quantity of liquid, regardless of cost, would be most difficult. The dread of a rescue station being caught with a short supply over a holiday weekend in the winter, with air transportation at a standstill, led to the belief that with other suitable equipment available, the Department of Mines did not feel justified in carrying on with the testing of liquid oxygen breating apparatus.

No manufacturer of such apparatus has claimed that his equipment will give protection for the specified 4-hour period, and thus our second reason for not going ahead with its testing.

Three types of compressed oxygen breathing apparatus, each claimed by the manufacturer to provide protection for four hours were studied. Results of previous testing by Government agencies in West Germany, South Africa, and Australia had been accepted as factual. Each of the three apparatus carried its oxygen supply in a 2 litre cylinder compressed to 200 atmospheres (3000 p.s.i.). Disposable regenerator cartridges are used and they too are identical and interchangeable.

The deciding factor in accepting one apparatus over the others for this test was the difference in weight of the equipment to be carried. The Drager BG174 had a total weight, with charged cylinder and regenerator in place, of 27.12 lbs., versus approximately 37 lbs. for each of the other two. The liquid oxygen apparatus also weighs 39 lbs. at beginning of use, but the weight is reduced as the liquid is vaporised.

Six units of the BG174 were obtained on loan for these tests. Two types of tests were carried out; (a) An endurance test, where the apparatus was worn by mine rescue teams performing continuous work or travel underground for a full four hours. (b) A test while being worn by mine rescue crews subjected to elevated temperatures.

Results of these tests, over a 5 day period, with the apparatus worn by 56 men, all of whom took part in the McIntyre fire, proved to our satisfaction that the Drager BG174 would provide complete breathing protection for a full four hours of exertion as extreme as it could ever be possible for workmen to be subjected. In the elevated temperature test, 20 men worked for 1 hour in temperatures of 150 - 156 degrees, with no discomfort.

Following these tests, the Ontario Mining Association requested the Ontario Department of Mines to proceed with the conversion from 2 hour apparatus to 4 hour Drager BG174 in all mine rescue training areas of the Province.

This was completed, 369 such apparatus are now in use in Ontario training, and all those concerned are completely satisfied with their performance.

The decision of the Ontario Department of Mines, later becoming the Mining Health and Safety Branch of the Ministry of Labour, to adopt the Drager BG174 apparatus as first-line breathing equipment for fighting underground mine fires has been justified. Every Province and Territory in Canada followed suit, and now some 1200 are in use. Five Toronto, and also Montreal and New York area fire departments have found a use for them in subway and high-rise building fires.

Since the purchase of the BG174's in 1966 by Ontario, they have been in continual use, some of them as much as four days a week, in training. At least 80 underground fires have been fought with them in the intervening twelve years, and during that total intensive use of the apparatus, no major fault, nor any trend of minor ones have developed.

HIGH EXPANSION FOAM

Mention was made earlier in this paper concerning the use of High-Expansion Foam underground during the fire at McIntyre. This application was so successful, it was agreed by both the Industry and the Department of Mines that a number of similar units be purchased for the purpose of training rescue crews in its use.

Accordingly, six High-Expansion Foam generators were obtained, powered by a 1 cylinder, 6 hp. diesel engine, and capable of producing 6000 cu. ft. of 1000/1 ratio foam per minute. These are maintained at strategic locations in the Province, and being self contained, can be moved quickly if required during a fire. The weight of the unit including the engine is 330 lbs., and its size is such that it can be carried in our mine rescue trucks. Nylon tubing is used to conduct the foam through openings in barricades or doorways.

Due to the successful use of our first six high expansion foam generators, seven additional 6000 c.f.m. units were purchased in 1976. A number of Ontario mines have purchased their own foam generators for additional protection. All are portable, self-contained, diesel-powered and for use either underground or on surface. These latter units are lighter and more compact than the original six.

SUNSHINE MINE, IDAHO

The disaster I am about to relate, while not occurring in Ontario, had a profound effect on mine rescue and on the general practices of the mining industry in Ontario. For this reason, I am including it in a paper dealing with Ontario Mine Rescue.

The worst disaster in North American Metal Mining history occurred on May the 2nd, 1972, at the Sunshine Mine in Northern Idaho. Ninety-one men died as a result of a fire believed to have been started by the spontaneous heating of flammable refuse.

It is known that many varieties of refuse, paper, rags, oil containers, and scrap timber were dumped into waste rock used for backfill in mined-out stopes. History repeated itself after forty-four years, as the deaths of thirty-nine men in Ontario in 1928 resulted from a fire underground caused in exactly the same manner. While this poor practice of disposing flammable material underground was the prime cause of the fire, it was only one factor in the death of the ninety one men. Some of the other factors, as quoted in the U.S. Bureau of Mines "Report of the Sunshine Mine Disaster of May 2, 1972", released in March 1976, were:

1. A 20 minute delay in injecting the stench warning, while supervision tried to ascertain the exact condition of the fire.
2. Ineffectiveness of the stench warning system. Subsequent testing of the system during investigation revealed the system contained about 20% of the necessary amount of ethyl-mercaptan for the quantity of air entering the mine.
3. Failure to conduct evacuation drills. No drill had ever been conducted, and employees were not trained in emergency procedures.
4. Inadequacy of the emergency fire plan and the emergency escapeway system.
5. No provisions for breathing protection of underground hoistmen so the hoists could still be operated to bring men up from the lower levels. The death of the hoistman on 3100 level of No. 10 Shaft, condemned every man still to be hoisted from below 3100.
6. Inadequate telephone system. The single circuit, connecting hoistroom, shops and shaft stations was ineffective because so many persons attempted to use it simultaneously.
7. No management official was designated to be in charge of the entire operation in the absence of top mine officials at a stock-holders meeting.
8. No check-in, check-out system was in effect. Miners were checked into the mine in shift bosses' time books, and the books taken underground. Some were lost with the shift bosses. Mechanics and electricians entered the mine without any control. Cap lamps missing from the charging racks were the only means of indicating who might be underground, and then too, extra lamps had been sent underground to replace defective ones.

9. Refuge stations were not provided on levels of the mine from where there were no second exits.

These are only nine of some thirty factors identified by the USBM as existing on May 2nd, 1972, which contributed to the deaths of ninety-one men underground from suffocation by carbon monoxide and smoke. That fire is now history. It was a disaster that should not have occurred. What has been learned from it that may prevent its recurring right in your own mine? Ask yourself, "Are you satisfied with your fire procedure?" "Has it been reviewed and revised since 1972?" "Do your new employees know what ethyl mercaptan smells like, and what it signifies?"

These questions were indeed asked. Many of the lessons had been learned from previous fires. Some of the factors contributing to the severe losses in this fire had supposedly been eliminated in Ontario mines, but the entire picture was studied once more.

OTHER ALTERNATIVES

The advisability and need for refuge stations underground is recognized, and protection for hoistmen is vital. The use of self rescuers to be worn by every person underground is debatable in hard rock mines. Maintenance, with little or no use over periods of often many years, could be impractical or even impossible.

Few men underground have the physical stamina and endurance to allow them to climb the more than 2000 feet of ladders to surface. Not all mines have a second, suitably located, continuously manned, operating shaft and hoist. All mines though have, or could excavate, short stub drifts which, at small additional cost, could be converted and maintained as life saving "Refuge Stations". In properly equipped refuge stations, workmen could assemble and remain in safety during a mine fire or underground power failure for hours or even days.

Refuge Stations are becoming more numerous in Ontario mines and in many cases they are used daily as lunch rooms or dispersal areas. This keeps the workmen familiar with the location in event of an underground fire.

FRESH AIR BASES IN DEEP MINES

Fires occurring in deep mines present special problems, as was the case at the McIntyre Porcupine fire in 1965. Excessive distances of travel for rescue teams under oxygen can overtax the capacity of the self-contained breathing apparatus or the stamina of the rescue men.

A refuge station which would serve as an Advanced Fresh Air Base can be invaluable, if located in the vicinity of a winze collar. Within this area, breathing apparatus could be re-charged; equipment, air and oxygen cylinders could be brought from surface and stored; stand-by rescue teams could be kept in readiness, reasonably close to the working team; and directives could be passed to teams for immediate action.

PROTECTION FOR WINZE HOISTMEN
(and operators within the tower of a friction hoist on surface)

One of the most important lessons learned from the 1972 fire merits particular emphasis. That lesson is the vital need for a hoistman to have the capability of remaining at the controls of his hoist.

An enclosure under positive pressure, with air conditioning, would be ideal provided that nothing could interrupt the supply of makeup air.

A further system of emergency breathing protection for the hoistman is required in Ontario and instructions follow:

1. That all underground winze hoistrooms be equipped with one or more units of self-contained "Demand" breathing apparatus, installed on or adjacent to the hoistman's platform, as to be conveniently available; that one or more fully charged 300 cu. ft. cylinders of compressed breathing air together with facilities to enable the hoistman wearing the Demand apparatus to be connected to the large cylinder by flexible high pressure hose so that he may breathe pure air directly from the large cylinder.
2. Where hoistrooms of friction drive hoists on surface are situated within the tower, that identical breathing equipment to the preceeding be installed. These hoistrooms may become contaminated from an underground fire if the shaft is, or may become, upcasting.
3. That identical equipment be installed near the tops of all shafts and winzes for use by the cagetender to enable him to make repeated trips down a contaminated shaft to evacuate mine workmen.

4. That sufficient numbers of hoistmen and cagetenders be adequately instructed in the use of Demand apparatus with the auxiliary equipment, and that refresher training be provided for each of them at least every six months.

5. That the above equipment be maintained in clean, dry locations, and that it be inspected and a record of such inspection be made monthly.

HOLLINGER MINE FIRE, 1928

The need for comprehensive mine rescue training in Ontario got abrupt recognition in February, 1928, when an underground fire in the Hollinger Mine at Timmins, caused the fatal asphyziation of 39 men.

Men trained in the use of rescue equipment or the equipment itself simply did not exist in the province and the U.S. Bureau of Mines received a cry for help. The Bureau responded quickly by despatching a special train with equipment and trained men from their Pittsburgh, Pennsylvania station to Timmins.

Prior to the Hollinger disaster, underground mining had been carried on in Ontario for several decades without serious underground fire incidents and a conviction that only coal mines were susceptible, had developed. There was an immediate about face. A Royal Commission to a mine rescue station was established at Timmins in the following year. In 1931, a station was set up at Sudbury and within a year, the Kirkland Lake station was in operation. All stations conducted training programs. These have been increased to where there are now eight main or central stations, and where necessary thirty-one sub-stations have been established.

While minor underground fires are common, serious fires are few in hardrock mining. It was not until 1938 that a Kirkland Lake mine fire tested the mettle of the mine rescue establishment there. The emergency was handled efficiently with no loss of life. In 1946, a major fire at the Teck Hughes mine was dealt with, again without loss of life. A fire in the East Malartic mine in Quebec occurred in 1947. Ontario teams of volunteers and equipment from Timmins, Kirkland Lake and Sudbury worked together in the rescue operation. Unfortunately, 11 miners lost their lives. This combined operation pointed out the serious need for complete standardization of all training procedures and mine rescue equipment.

The 1965 shaft fire at the McIntyre Porcupine mine was a severe test. Over a three-week period as many as 135 mine rescue men worked together under extreme conditions of heat, smoke and gas. None was injured; there was no equipment failure and no man withdrew from the task.

In Ontario in 1981, there were 800 active mine rescue team members, and 225 trained supervisors attending regular full-day training periods, once every two months.

Each new trainee undergoes an intensive 3-day Basic Course of surface instruction and underground practical training, concluding with a period of wearing breathing apparatus in heavy smoke.

Basic Training is followed by Standard Training, which is the practical application underground of the surface lectures.

The subjects taught in these courses include a working knowledge of all gases that could ever be found in a mine and their physiological effects on man; the knowledge and practical use of portable detectors of gases such as oxygen, carbon monoxide, methane, sulphur-dioxide, hydrogen sulphide and the nitrous gases.

The primary subject taught of course, is the use of the many types of protective breathing apparatus. Without this, you must realize, there would be no such thing as mine rescue.

To complete the Standard Training Course, and to follow on into Advanced Mine Rescue, the trainee must learn to use the auxiliary equipment necessary to test, maintain, and to make minor repairs or adjustments to the breathing equipment; the high pressure breathing-air compressors and oxygen transfer pumps; the re-charging of oxygen cylinders to pressures as high as 4,000 p.s.i. He is taught mine rescue team emergency practices, the establishing of advanced fresh air bases, the specific duties of a mine rescue team captain and methods of communication between team members and between the team and the fresh air base.

As he progresses, the trainee is taught the many causes, the classification and the methods of controlling underground fires.

Examinations are held at the completion of each basic, standard and advanced course, and appropriate certificates and seals are awarded. A trained mine rescue man is a valuable asset to any mining company, or even to an industrial or commercial firm, should he later decide to leave the mining industry. One of the unseen benefits derived from mine rescue training, is that the man automatically becomes more fire-hazard conscious, just as a trained first-aid man becomes more accident-hazard conscious.

While mine rescue training involves the saving of lives and extinguishing of underground fires, another important service involves the provision and dissemination of information and lessons learned from fires which have occurred.

Fortunately heavy loss of life in metal mine fires is (shall I say) rare. This hasn't just happened, but has been brought about by the serious co-operation by industry, labour and government. Mining Acts are very specific on fire regulations and the mining industry spends literally millions of dollars in fire prevention, good fire equipment and mine rescue training.

A fire, even a serious one, is not all loss, if a lesson can be learned from it that will prevent a similar one in the future. Unfortunately, maybe due to complacency, sometimes a lesson isn't learned, or the information wasn't spread far enough, or it happened too long ago to be remembered.

The Ontario Ministry of Labour and the staff of the Mining Health and Safety Branch sincerely appreciate the co-operation and wholehearted support given by the Industry to all phases of Mine Rescue Training.

It has been a pleasure for me to speak today on a subject familiar to many of you. Some of you may have been members of mine rescue teams, others as supervisors and directors. I have said many times, that I am proud to have been associated with you. We tremble when we read stories of what happened at Sunshine Mine, Idaho in 1972, and at No. 12 Mine at Sydney. None of us can become complacent. The Ontario Mining Industry through the Government of Ontario have always endeavoured to purchase the most efficient and up-to-date mine rescue equipment available. The mines have supplied for training, their very best employees. The Ontario system of training and the Ontario Mine Rescue Handbook are in use throughout all of Canada, and it is even creeping into the United States, the Philippines, Australia, India, Pakistan and several European countries. In spite of a program the Ontario industry is particularly proud of, they are nevertheless continually vigilent and ever trying to anticipate, adapt and improve.

people were underground. This contravened the mine procedures. You are quite right. There would have been a fire watch and yes, there would have been a burning permit issued if there had been a work order issued for that it would have been under control. This is one of those instances where the two guys came out by themselves, went underground and did the job that they not had time to complete the night before.

Q. Unrecorded question.

A. Unless there is a single, very responsible person who is to maintain, and we find the same thing with our breathing apparatus. We rely on our mine rescue training officers who are in charge of each station to thoroughly test each apparatus once a month and make a report on them, which must be sent to Toronto. If it was left to let's say a light duty man in a mine, and this often happens where maintenance work such as this is often left to a light duty man at the mine, I think you know, and I know and everybody else knows that sometimes they slip up on it. This is my point. You have to have somebody that is absolutely reliable. For example, I know of one instance where there were 24 apparatus stacked at this property. These apparatus had been installed. Actually, it was in Churchill Falls, a power plant in Labrador, and while I was doing consulting work for them, we established a mine rescue station, we had a mine rescue truck, we had all the equipment in very good working location. Once the Churchill Falls Power Corporation took over, the checking of this apparatus was assigned to one of the workmen and once a month he did make tests and he would check this equipment over. But he would pull out one piece of equipment off the shelf, put it on the table, open the lid, close the lid and sign the slip. He was not even checking the pressure on the cylinders. This is my point. This is how things can get so lax.

Q. Was anything developed in order to come up with an answer regarding safe working periods of workmen wearing breathing apparatus in high temperatures?

A. No. We did not. We do know that we had doctors examine these men after the full hour. Their pulse rates were higher, yes, definitely, but they returned to normal within the 20 minute period of rest. No time limit has been set up, we have not established any program for limiting or setting up the time limit. To a large extent the judgement is left to the captain of the mine resuce team. And that is one of the duties, we feel, he will assume. I know of one other instance where we ran a test, this was at one of the mines in which there was a heating condition, and I went in with the team, into this temperature of 150 degrees, wearing dragger apparatus, and at the end of that time, we were in there for about 25 minutes, and when I came out, my pulse rate, I checked it myself, was 140, from the normal 72. I had no business going in. I was above the age, I was not a qualified mine rescue team member at the time, but I went in with them. I did not make a second trip in. The other teams did make the second trip in after they had had their rest period. But I can't answer your question about what specific time should be allowed in those particular temperatures.

DISCUSSION FOLLOWING PRESENTATION OF GEORGE McPHAIL

Q. Mr. Gorie

I think I did understand Mr. McPhail to say during his presentation that the use of mine rescuers in mines was debateable. I would like to take the indulgence of this meeting for a few minutes to contribute to that debate.

A. May I clarify that one point. I mentioned that the use of self-rescuers in hard rock metal mines.

Mr. Gorie:

This is a very important point, and one which this symposium should obviously address itself, Mr. McPhail. All I did want to do was to contribute to British experience in this respect. In 1953, we had one of our worst mine disasters ever where over 80 workmen were killed and then later on in about 1959 we had another 40 men killed with an underground fire. Around 1968 we again had a number of men killed in an underground fire. We had been conducting trials with a carbon monoxide filter self-rescuers at one colliery in each of the National Coal Board areas up to that point, but the decision was then made that all underground workmen would be equipped, that was about 1968. So that meant that in 15 years prior to 1968, somewhere around 150 men have lost their lives due to underground fires. Since 1968, there have been no underground workmen in the United Kingdom who have died as a result of an underground fire. I think that is a very significant statistic.

A. Yes, I agree wholeheartedly, and in no way am I questioning the use of self-rescuers, particularly in coal mines. My emphasis is that in hard rock mines, where experience, I think world-wide, has shown that these are a rare occurence, they do happen occasionally. But again, I have seen equipment that has been stored at a mine for years and years, without being used, tested or even looked at, and then a man who has had no training, no experience with that apparatus is expected to put it on and survive. I am not questioning it. I almost took that paragraph out of my paper for that reason. I knew that it was going to be controversial. I am glad it has and I am glad now that I left it in. I wanted to emphasize, dealing only with hard rock metal mines.

Q. Joe Burke, Safety Inspector

A. Yes, that is quite right. However, in this particular instance, these two workmen came out on Saturday to finish a job that had been started on Friday in order to allow the work to be continued on Monday. These men came out by themselves, they went underground by themselves. There was no work order, there was no burning permit. These men worked exclusively by themselves. Very few people, in fact only one man, knew that these

people were underground. This contravened the mine procedures. You are quite right. There would have been a fire watch and yes, there would have been a burning permit issued if there had been a work order issued for that it would have been under control. This is one of those instances where the two guys came out by themselves, went underground and did the job that they not had time to complete the night before.

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Q. What is the maximum age for a mine rescue team member?

A. 45. 45 is the maximum age for an average mine rescue team member.

Q. Do you have any women mine rescue team members?

A. Actually there is one instance, and this occured up at Pickle Lake. There was a nurse working up at the mine in her capacity as a nurse and she felt, the impetus came from herself, she should be able to travel underground with the mine rescue team in case her services were ever needed underground. She was trained. She went through the full training as a mine rescue team member. As a matter of fact, she was on the competition team two years ago that won the provincial competition. That is the only female to my knowledge that has been on a mine rescue team.

Q. Are there any women working underground in the mines.

A. 4.

MINE CRISIS MANAGEMENT AND INSPECTORATE INVOLVEMENT IN THE UNITED KINGDOM

BY

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SUMMARY

The historical development of mine crisis management procedure in the United Kingdom is described as a background to current practice with the applications during the inundation at Lofthouse Mine and, more recently, during the explosion at Cardowan Mine being used to demonstrate the wide ranging nature of the problems encountered. The close technical involvement of HM Inspectorate of Mines and the mandatory controls over rescue and recovery operations then lead into a description of the style of investigation, report and consultation normally adopted after a serious mining accident in the United Kingdom.

1. INTRODUCTION

The general framework of mine crisis management procedures in the United Kingdom was formed by a Departmental Committee on Mine Rescue Work appointed to enquire into and make recommendations on all aspects of rescue work in mines, which reported in 1926. As a result, mining safety legislation was laid down which still provides the main basis for the present regulations and covering mine crisis management. The twin objectives of these regulations are to ensure that every mine is provided with a skilled mines rescue service and that on any occasion where rescue operations have to be instigated, there is also an efficient organisation to ensure that the rescue operations are conducted with the minimum of risk. There has been little change in this basic structure over the course of half a century which might suggest lack of progress but, on the contrary, a close examination of the subject reveals the perception and skill which the Committee applied to their work.

Unfortunately, the history of coalmining has been fraught with disaster and there has been ample opportunity in which to test and try the mechanisms of mine crisis management. Mistakes have been made and lessons learned with the experience so gained leading to procedures which have been honed to a very fine edge. The specific arrangements for mine crisis management are encapsulated in the "Scheme of Emergency Organisation" which the National Coal Board require a mine manager to prepare. This meets his statutory obligation under mining safety legislation which allows a measure of flexibility but also imposes a number of mandatory requirements which are common to all schemes. Legislation notwithstanding, the view of most mining engineers in the United Kingdom is that mine crisis management arrangements depend for their efficiency on the successful marriage of two very highly developed skills, namely, that of a specialist rescue service with a highly professional management team. Like any successful marriage, however, it benefits from free and full cooperation and consultation with the rest of the family, in this case the Trade Unions and HM Inspectorate of Mines who, although each having their separate roles in a mine crisis, all share the same common objectives.

Choosing a case study which portrays the full picture of mine crisis management in the United Kingdom is more difficult. There has certainly been no lack of disasters from which to choose but the dissimilarity between separate incidents ranges widely. For this reason, reference will be made to two separate incidents, one being the crisis following an underground inrush of water at Lofthouse Mine in 1973, where the mine crisis management organisation was exposed to the full spotlight of world attention for over a week, and the other, the incident at Cardowan Colliery earlier this year, where 41 workmen involved in an underground firedamp explosion were all rescued without loss of life. Lack of space permits only the briefest descriptions because it is considered that a more important aim of the Symposium is a study of the details of the scheme of emergency organisation, how it was developed and how it works in practice.

It would be remiss of the Author, as a member of HM Inspector of Mines, not to refer to the special role of that Inspectorate in mine crisis management. By far their heaviest involvement is in the subsequent investigation, report, and recommendations which inevitably follow any serious mining accident but there are sound reasons for their technical involvement in rescue and recovery operations during any mine crisis.

2. EVOLUTION OF EMERGENCY ORGANISATION AT MINES IN THE UNITED KINGDOM

When considering the degree of hazard facing any rescue worker entering an irrespirable atmosphere in the wholly hostile underground environment likely to be encountered after an explosion, in the highly charged emotional state associated with serious casualties and, certainly not least, in the sheer physical discomfort of wearing a self-contained breathing apparatus in confined spaces while carrying out arduous work, it is truly remarkable that this type of work which is promulgated to save life, can itself be carried on without resulting in serious loss of life. Undoubtedbly, there have been serious accidents during rescue operations, often for no other accountable reason than psychological strain, but the overall performance of rescue work in the United Kingdom mines since the 1926 Rescue Committee Report must be recognised as one of outstanding achievement when considered in relation to the risks which are involved. Such standards can only be achieved where the levels of knowledge and skill of the rescue personnel, the standard of their rescue equipment and the discipline of their service are all of the highest order.

The 1926 Rescue Committee had been faced by many serious problems in the conduct of rescue work preceding its deliberations and they decided that the only real answer for the United Kingdom mining industry lay in the provision of a Central Mines Rescue Service. Accordingly, they recommended that new legislation should make it mandatory for a mine to be linked to a Central Mines Rescue Station and this was the first major step in the establishment of the present Central Mines Rescue Service.

Due cognisance had also to be taken of the fact that when rescue operations were to be mounted at a mine, serious hazards would arise unless these operations were very carefully organised and controlled by a senior level of management. In consequence, the formulation of emergency management procedures which must be followed during any rescue operation were seen as essential adjunct to the provision of a rescue service. The general statutory requirements relating to mine crisis management and rescue operations are illustrated in the orbital diagram at Fig. 1. Arrangements relating to the provision of an efficient rescue service, and the other requirements on strict management control, are both seen to lead to the common objective of the safe conduct of rescue operations. Subsequent reference will be made to each aspect of the organisation shown on the diagram in the text of the paper.

Because high standards of maintenance of equipment and of supervision are of such importance to the operational safety of rescue operations, certain requirements have been laid down in statute. These requirements are also illustrated in an orbital diagram at Fig. 2. They are based on the concept of the Central Mines Rescue Station at the core, its own management structure, the training of rescue personnel and the provision of facilities for the safe conduct of rescue operations under the direction of management at the mine. Two types of rescue organisation are permitted in the United Kingdom and management can opt for either by local agreement binding management in the locality to the preferred arrangements. In Scheme "A", a rescue corps is maintained in permanent residence at the Central Rescue Station. Scheme "B" does not have a permanent corps. Both schemes invite volunteers at each mine to train in rescue work but in scheme "B" the numbers required and the intensity and frequency of their training is necessarily greater than in Scheme "A". On the choice of rescue service so offered, it must be said that the speed at which a rescue operation using breathing apparatus can be mounted depends largely on the speed at which a fully equipped rescue team can be assembled ready to descend the mine. On speed alone, therefore, the preference in this respect would be for the Scheme "A" Rescue Station with its permanent corps, since under Scheme "B" arrangements rescue team members may be dispersed throughout the mine or may have to be summoned from home. For local knowledge of the mine, however, rescue brigades from the mines concerned would usually carry some advantage.

3. PROLONGED MINE CRISIS AT LOFTHOUSE COLLIERY

At 2.00 a.m. on 21st March, 1973, as a team of coalface workers was shearing through a narrow longwall coalface about 200 metres depth from the surface at Lofthouse Colliery in the Yorkshire Coalfield, an inrush of water occurred which focused world attention on the mine for eight days, as a dramatic race against time began in the efforts to rescue seven workmen who were trapped.

As underground officials and workmen withdrew from the vicinity of the affected face, the alarm was raised at the surface and the scheme of emergency organisation activated. A call was sent to Wakefield Central Mines Rescue Station some 8 kilometres distance from the mine and by the time the permanent rescue corps had arrived, it was established that a number of workmen employed on the coalface were still missing. A rescue effort was immediately mounted to try and find them but both roadways providing access to the coalface were found to be sealed by flooding at a distance of about one kilometre back from the face.

Meanwhile, an inspection made of the surface area in the general location of the coalface revealed the collapse of surface ground around some old shafts and it was then clearly evident that an inundation of considerable magnitude had occurred from old uncharted workings.

After assessing the results of the first inspections by rescue teams, a group of senior management who had been quickly assembled at the surface of the mine, decided that the action which had already been taken to start installing pumping equipment to clear the flood water blocking the access roads to the face, should be supplemented by a

simultaneous action to:

(i) drill a borehole from the surface into the district;

(ii) block the inflow of any further water into the coalface from the surface by sealing the old shafts which had been exposed in the collapse of the surface;

(iii) drive a small "piggy-back roadway" over the swilly causing the blockage;

(iv) explore the possibility of a rescue team experienced in sub-aqua work to pass through the water and sludge blocking the roadways.

In the event, pumping of the semi-solids and sludge causing the blockage proved impracticable with the pumps which were readily available. Similarly, attempts by the sub-aqua mines rescue teams to pass through the sludge likewise proved completely impossible and the only recourse left in the rescue effort was to proceed as quickly as possible with the "piggy-back" drivage over the blockage. Needless to say, this became a highly charged and emotional race against time, with miners who were close relatives of those trapped being involved and achieving almost superhuman feats of drivage with the intervening distance of some 60 metres being completed in just over 2 days. Thereafter, rescue teams were able to pass through the blockage and proceed forward in chest-deep sludge wearing breathing apparatus. With the ventilation blocked, however, firedamp had built up to dangerous levels and drilling from the surface was stopped short of holing into the district for fear of ignition. As subsequent rescue teams progressively worked their way forward, the atmosphere became increasingly irrespirable and when the roadway was again found to be blocked nearer to the face, all hope of rescue of the trapped workmen alive had to be abandoned.

The rescue effort was eventually concluded some eight days after it had started. As can be well imagined of any such setting exposed to the full glare of public attention, compounded as it was by the extremely arduous nature of the underground conditions, and with every decision to be made involving some element of risk, officials in charge of the rescue operations and senior members of HM Inspectorate who had been present throughout the incident were placed under severe stress as was the scheme of emergency opganisation itself. The relatives of those workmen trapped and the public at large had the right to be kept fully briefed on what was happening and reassured that every step which reasonably could be taken was in fact being taken In this respect the level of public accountability could not have been higher. Balanced against the obvious public pressure to make the rescue attempt was the safety of the rescuers themselves and eventually of the rescue teams pressing forward under the most arduous circumstances in an irrespirable atmosphere. Doomed as the rescue attempt was to failure, however, what the operation did demonstrate quite conclusively was that the Scheme of Emergency Organisation could cope with most severe type of mine crisis by meeting the demands of the situation and yet also ensuring the safety of all involved.

4. SUCCESSFUL RESCUE OPERATION AT CARDOWAN COLLIERY

In contrast to the Lofthouse Colliery inundation, the explosion at Cardowan Colliery on 27th January, 1982, was chosen as a second case study because of the outstanding success of the rescue operation, namely, that all 41 workmen who were involved in the substantial underground explosion of firedamp were rescued without loss of life from a longwall coalface in a narrow seam some 5 kilometres from the shaft bottom. The explosion occurred during a morning production shift when a plug of firedamp was accidentally blown out of a gas-fast heading into the main intake airstream to the coalface where it was ignited by a frictional sparking at the shearer drum. The scheme of emergency organisation for the mine was immediately activated when the lamproom attendant at the surface received a telephone call directly from the coalface at 8.57 a.m. The Central Mines Rescue Station at Coatbridge, some 10 kilometres distance from the mine, was then notified and its permanent rescue corps arrived at 9.10 a.m. ready to go underground wearing breathing apparatus.

During the course of rescue operations it was quickly established that re-entry into the district was safe and all available officials and workmen who were underground at the time were deployed to the assistance and recovery of the injured workmen. As a result, the last of the injured workmen had been rescued from the coalface, transported the 5 kilometres to the shafts, brought out of the mine and taken to hospital where they were undergoing intensive treatment within 2 hours 40 minutes of the explosion having occurred. It is one of the enigmas of safety engineering that there is no way of measuring the efficiency of such an operation in the number of lives which were saved. What is not in doubt in this case, however, is that the speed with which the emergency was raised, the use of self-rescuers, the rapid deployment of first-aid and medical services and the short period elapsing before the seriously injured were undergoing medical care in hospital, did in fact save lives.

In terms of the types of mine crisis to be managed there could indeed be no stronger contrast between the Cardowan and Lofthouse incidents. At Cardowan the explosion was over in seconds and, although injured and dazed by the explosion, an official was able to go to the telephone and raise the alarm. All workmen were equipped with self-rescuers allowing not only self-rescue but also to aid the rescue of others. The prompt activation of the scheme of emergency organisation ensured the participation of all services and strict control over the total operation from its very start. In short, the organisation functioned exactly as intended and the crisis, as such, was virtually over shortly after it had begun. At Lofthouse the incident required a sustained rescue effort of the most arduous and hazardous nature over a prolonged period where there was very serious concern about the safety of the rescue workers.

5. MINE MANAGER'S SCHEME OF EMERGENCY ORGANISATION IN THE UNITED KINGDOM

The general arrangements for control procedures adopted during emergencies at mines of the National Coal Board in the United Kingdom are illustrated at Fig. 3. Central to all control procedures is the mine manager's scheme of emergency organisation which is drafted to meet the manager's statutory duty under the rescue regulations that he should "... make rules allotting to competent persons the duties to be performed by them on any occasion on which rescue work is about to be carried out ...". The regulations go on to make further provision regarding rescue arrangements but relative to statutory requirements governing the management structure of the mining industry in the United Kingdom, the mine manager would exert general direction over the rescue operations as the Incident Director and would usually be advised by senior mining engineers, including experts in the specialist subjects involved as well as a Senior member of the Inspectorate.

The nerve centre of the organisation is the Central Control Room where a detailed log of all instructions, actions and other relevant information is kept by Controllers of Senior Managerial status who would be present round the clock and would be charged with the responsibility of implementing the Incident Director's instructions of which the following requirements are mandatory:

(i) Authorisation and registration of any person entering the mine during the emergency

Persons authorised to go underground would be issued with an envelope with three similarly numbered but differently coloured tabs, the first of which would be exchanged for a lamp in the lamp room, the second given to the banksman on proceeding underground and the third to be retained on the person while below ground. The process is reversed on coming out of the mine with the tabs being collected and returned to the underground control room.

(ii) Organisation of rescue workers into teams

This duty would normally be delegated to the rescue station superintendent and discharged through his Rescue Station Instructors. Since the logistics of a large rescue operation require careful organisation with teams of fully trained part-time rescue workers being brought in from other mines, a separate rescue operational control room should be provided to allow close control over the organisation of the teams and their briefing prior to descending the mine. Equally important is their later debriefing on returning to the surface with appropriate records being kept of their work and reports.

(iii) Servicing and Testing of Breathing Apparatus

The arrangements for servicing and testing rescue apparatus prior to its re-use would be decided by the rescue station. In this respect a detailed specification for a surface rescue room has been prepared as a guide for mines in the United Kingdom which should meet even the most extreme exigencies and allow all servicing to be carried out at the mine surface under the direction of the rescue controller. A suitable layout is illustrated at Fig. 4.

(iv) Medical Examination of Rescue Workers

The Rescue Regulations require medical examination of rescue personnel during their involvement in an emergency and a place with suitable facilities must be provided for this purpose but the duties of medical officers in a mine emergency range much wider, especially at the outset in circumstances where a number of casualties have been experienced.

(v) Organisation of both surface and underground operations

Separate control rooms are normally provided for both surface and underground operations with the specific task of organising and managing the detailed implementation of the Incident Director's operational instructions. The deployment of manpower and other resources in this sphere of operations usually requires supervision by persons experienced in management.

(vi) Fresh-Air base for underground rescue operations

This is the final link with the rescue team prior to it entering an irrespirable atmosphere and the regulations are quite precise in their requirements as to control and facilities at this point. Other than for the purpose of saving life, a rescue team would not proceed beyond the Fresh-Air Base unless a stand-by rescue team was available and experienced rescue instructors present with suitable first-aid and reviving equipment provided. To ensure adequate control, an efficient communication system must be quickly established between this rescue control point and the incident control room.

(vii) Systematic monitoring of environmental conditions

The main purpose of environmental monitoring during any mine crisis is to ensure that the Incident Director has sufficient information to safeguard those engaged in underground rescue and recovery operations. In the schemes of emergency organisation used in the United Kingdom, the control procedure involves fixing underground locations where systematic monitoring will be carried out usually with hand held instruments but backed up with the collection of air samples for full gas analysis to correlate with the instruments. The results are carefully logged and charted in the central control room and the Incident Director immediately informed of any adverse trends by the Incident Room Controllers.

Of permanent importance to any such emergency and its management is the process of deciding policy and the overall action programme to be followed. In a complex underground incident, and history has shown that there are very few such incidents which are not complex, the range of expertise and experience required to ensure a safe and efficient operation is often outside the scope of any individual. A wide range of specialist advice will usually be required and normal practice at mines in the United Kingdom is for the most senior engineers available to form an advisory committee which will keep the whole operation under review and advise the Incident Director on any action which they consider should be taken. Needless to say, the structure of the Committee will depend on the type of incident and expertise required but it could be expected to cover all matters associated with the incident from the staffing of the control rooms at the outset, right through to the ultimate lifting of the emergency.

6. The Role of the Government Inspectorate During Mine Rescue and Recovery Work in the United Kingdom

Reference has already been made to a mine manager's statutory duties to set up a scheme of emergency organisation but it is also obligatory that when the scheme is activated, becauseof either a serious accident or of rescue operations being initiated, that HM Inspectorate of Mines must be notified by the quickest means available. There are strong historical reasons for this involvement which may be peculiar to the United Kingdom and which may be outside the remit of this Symposium but in order to be eligible for appointment as HM Inspector of Mines, a mining engineer must not only hold the relevant statutory qualifications for mine management but is also required to have at least two years experience in mine management. The clear intention of the regulations is that this managerial experience and expertise of the Inspectorate must be involved during any rescue operations. This part of the paper describes the specific role of HM Inspectors in the overall organisation of mines crises and his relationship with both management and workers in this respect.

When called to any such incident an Inspector's primary concern would be that of all other senior mining engineers in attendance, namely, to ensure that all possible steps have been taken to save life, succour the injured and safeguard those engaged in rescue operations. This may amount to no more than ensuring that there is an emergency scheme of organisation and that it is working, but simple as this may sound, the traumatic effect of a mine crisis involving serious casualties many of whom are possibly well known to officials at the mine, can have a devastating effect on any organisation. During these early stages, an inspector will seek to ensure that the rescue teams are properly directed on to the job, that the evacuation of the mine by non-rescue personnel is taking place and that a careful check is being kept of possible casualties.

Thereafter, the Inspector has specific duties which are closely linked to those of management but are nonetheless completely separate. In the United Kingdom, the Minister involved would normally make a statement to the House of Commons on which Members of Parliament could question the Minister in some depth on any related matters, and in consequence a full briefing would normally be required. The provision of this information would be the responsibility of the local Senior Inspector through the Chief Inspector. In the implementation of his own organisation, therefore, the Senior Inspector in the field would initially be concerned with both the input from an experienced Inspector into the crisis to ensure its orderly progress and thereafter the outflow of information on that progress. To achieve both objectives, he would wish an experienced Inspector to be in close touch with the Incident Control Room on a round the clock basis. This Inspector would be primarily charged with keeping a watching brief over the implementation of the whole operation, that any untoward developments which arise are quickly remedied and generally to assist in the smooth operation of the emergency organisation as required.

In the conduct of underground rescue operations, the Senior Inspector must also bear in mind that a primary objective of the whole scheme of emergency organisation is to ensure the safety of those engaged in the rescue operation. Reference has already been made to the Fresh-Air base and to the need to stipulate the staffing and equipment at this point of legislation. The reason for this level of priority is that where any mishap occurs in a rescue operation, it usually occurs at the cutting edge where the rescue operations are in fact being carried out. It comes without warning and if life is to be saved it will usually involve some form of reflex action. The needs of this type of situation warrants the presence of an Inspector and since this is the place of work where Inspectors have lost their lives or have been seriously injured they need no reminding that this is the place where the whole operation is most vulnerable.

On matters of policy relating to the conduct of both rescue and recovery operations, experience has shown that this is an area where close liaison must be maintained between management and the Inspectorate. The place to do this is in the Mine Crisis Advisory Committee where the detailed planning of the operation will be carried out and in this respect the Senior Inspector will require to be briefed in detail on the policy which is proposed. Leading from this liaison is the duty placed on the Inspectorate by law in the United Kingdom, that the Inspectorate must keep representatives of the Trades Unions fully informed of any matters affecting their safety. Where necessary, the Inspectorate would be obliged to conduct separate discussions with the Unions but the preference by far in an emergency situation would be to see this need fulfilled in the context of full cooperation and consultation between management and the workforce. In the United Kingdom, it is normal practice for senior representatives of the Trade Unions to sit-in on the meetings of the advisory committee and be involved in the development of policy discussions.

Finally, there is the special position which arises relative to role of the Inspectorate in the rehabilitation of the mine and its clearance for normal working. On this matter, the general approach which has been adopted in the United Kingdom is that this should be by agreement between management and representatives of the Unions but where difficulties or disagreement arises, then the Inspectorate would be involved. Indeed, this again is spelt out in mining safety legislation, but it is very seldom invoked because of the levels of consultation which have preceded this final step. In actual practice, a joint inspection of the mine by management and workers representatives would have been preceded itself by an inspection by HM Inspectors who would make their views known jointly to both management and the Unions.

7. INVESTIGATION OF SERIOUS MINING ACCIDENTS

Any reference to the involvement of the Inspectorate in mine crisis management in the United Kingdom would be incomplete without some comment on the investigation and reporting procedures which must inevitably follow a major mining accident. In this respect, the successful investigation of virtually any accident, whether mining or otherwise, rests on the ability to marshall all factual evidence into a logical progression which provides a full picture of the circumstances of the accident. When this is achieved, then the conclusions are usually self-evident, especially to expert eyes. Skilled investigation, however, like any other aspect of mine emergency planning, requires careful management and control, otherwise essential evidence may be lost and the full picture never known.

The three principal aspects of marshalling this evidence are, first, a detailed inspection and precise record of all relevant information at and around the site of the accident, secondly, the collection of

statements by witnesses detailing the events leading up to the accident, and finally, the forensic examination and testing of associated equipment, systems, etc. For this purpose HM Inspectorate in the United Kingdom is legally empowered to act on its own behalf but the clear preference is for an open style of investigation which commends itself to involving all interested parties at all stages of the investigation and also of keeping them fully informed as and when factual information becomes available. In such circumstances, the need for an Inspector's statutory powers of enforcement is seldom, if ever, required.

The dissimilarity of the circumstances of most mining accidents tends to preclude a dogmatic approach to any investigation but despite this, there are fairly precise guidelines which must be followed and special reference should be made to the following aspects of the investigation of serious mining accidents in the United Kingdom, namely:

(i) During rescue operations rescue teams are requested to keep a careful note of the location of casualties and of any equipment which they may have disturbed during rescue operations. In this context, the police are requested to make a careful examination of the clothing of any casualties.

(ii) As soon as the accident area has been declared safe, to arrange for the preparation of a detailed plan of the area in the proximity of the accident which will show the nature and location of all relevant data.

(iii) Make arrangements for the questioning of witnesses by a small team of Inspectors, with representatives of management and the Unions being present, during which statements will be prepared.

(iv) Where the primary cause of the accident is not known, to determine the sequence of forensic investigations which allows a process of elimination without damage to evidence.

(v) Where the primary cause of the accident is known, to organise a specialist team of investigators which will essentially produce the expert evidence on which the findings and recommendations will be based.

(vi) The preparation of the report, its submission to the initiating authority, its publication and finally, a discussion on the action following the conclusions and recommendations with all sides of industry.

Needless to say, this part of the Inspectorates involvement in any serious mining incident is the part which makes heaviest demands on the Inspectorate's resources. The emergency as such can very often be lifted within a few days and the rest of the mine cleared for normal working but it is not unknown for the residual work to extend into several years. For example, following the shaft winding disaster at Markham Main Mine in the East Midlands Coalfield in 1973, a specialist Committee was set up to enquire into and make recommendations regarding modern safety requirements for winding. The work of this Committee was not completed until 1979 with the publication of its final report but notwithstanding the complexity and duration of their deliberations, everyone conversant with the safety aspects of shaft winding practice has recognised the tremendous progress which has been achieved and that the effort expended has been more than justified. In such circumstances there are no simple short cuts to a full and satisfactory solution of the problems involved.

8. ACKNOWLEDGEMENTS

The author's thanks are extended to the Symposium Organising Committee for their invitation to present the paper, to the National Coal Board for its consent to quote from its Scheme of Emergency Organisation, to his own colleagues for advice and assistance in the preparation of the paper and finally to the Chief Inspector for his permission to present it to the Symposium.

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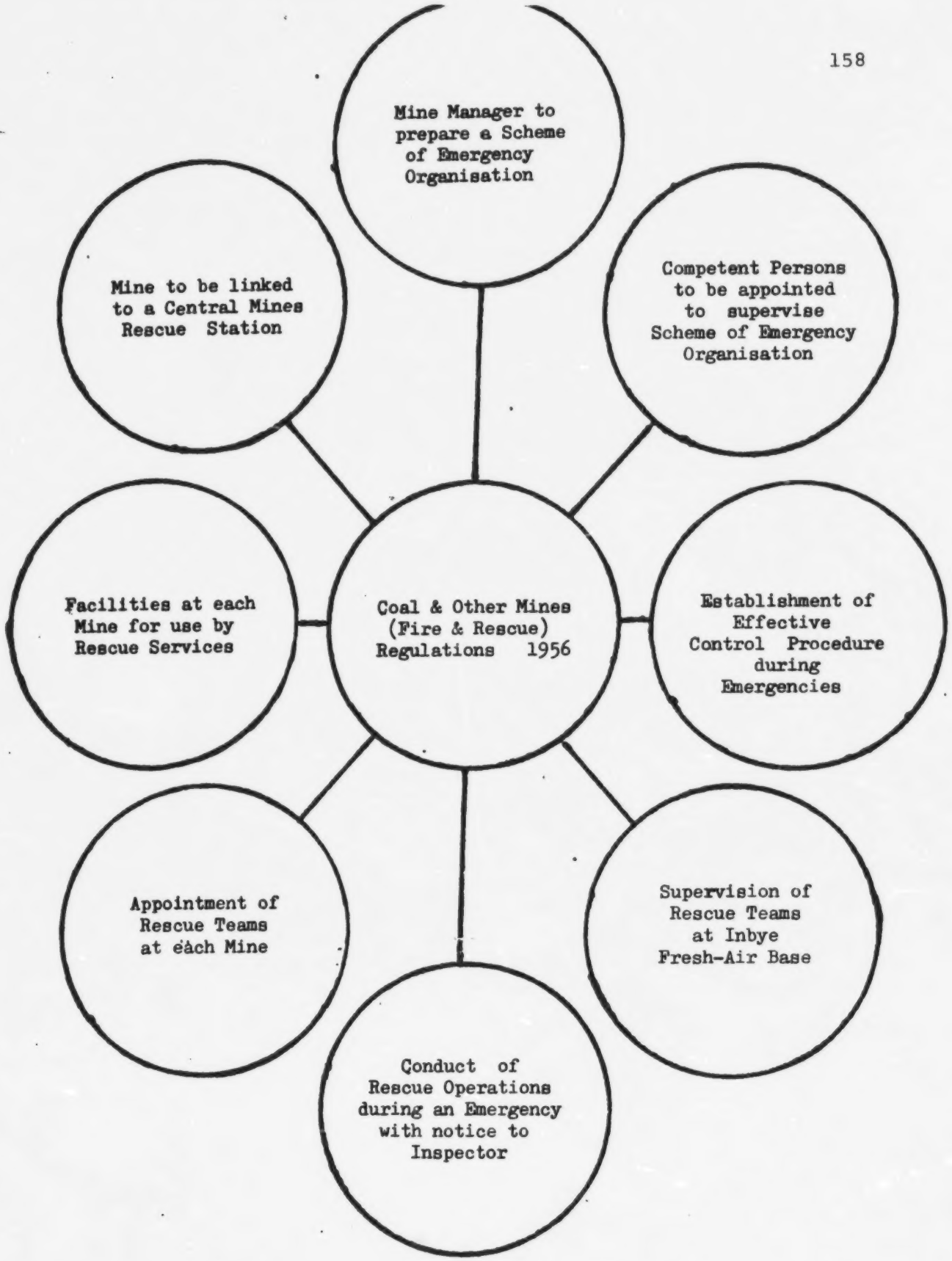

Mine Manager to prepare a Scheme of Emergency Organisation
Mine to be linked to a Central Mines Rescue Station
Competent Persons to be appointed to supervise Scheme of Emergency Organisation
Facilities at each Mine for use by Rescue Services
Coal & Other Mines (Fire & Rescue) Regulations 1956
Establishment of Effective Control Procedure during Emergencies
Appointment of Rescue Teams at each Mine
Supervision of Rescue Teams at Inbye Fresh-Air Base
Conduct of Rescue Operations during an Emergency with notice to Inspector

Fig. 1 - Statutory Requirements Relating to Mine Crisis Management

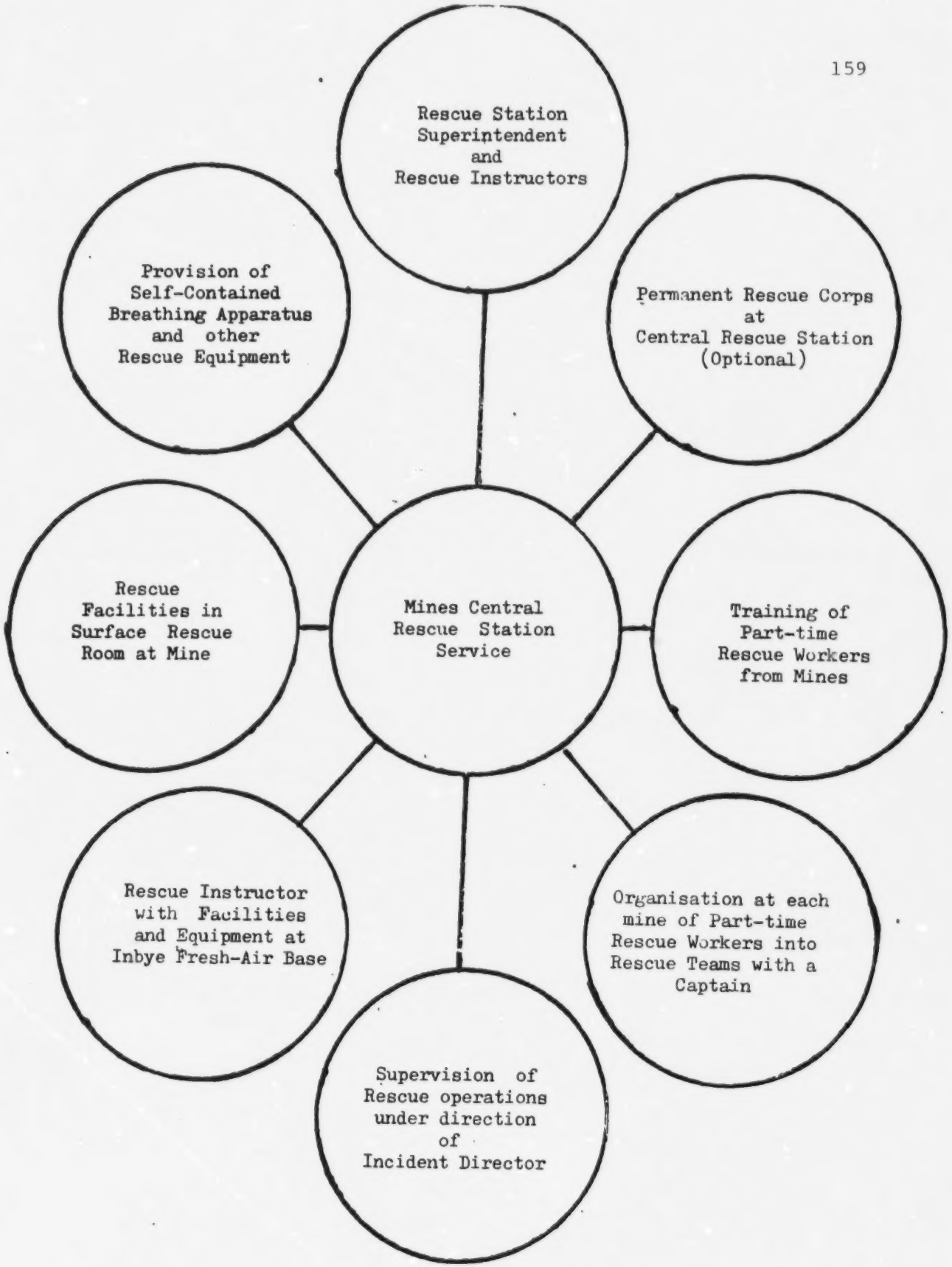

Rescue Station Superintendent and Rescue Instructors
Provision of Self-Contained Breathing Apparatus and other Rescue Equipment
Permanent Rescue Corps at Central Rescue Station (Optional)
Rescue Facilities in Surface Rescue Room at Mine
Mines Central Rescue Station Service
Training of Part-time Rescue Workers from Mines
Rescue Instructor with Facilities and Equipment at Inbye Fresh-Air Base
Organisation at each mine of Part-time Rescue Workers into Rescue Teams with a Captain
Supervision of Rescue operations under direction of Incident Director

Fig. 2 - Statutory Arrangements Relating to Central Mines Rescue Organisation

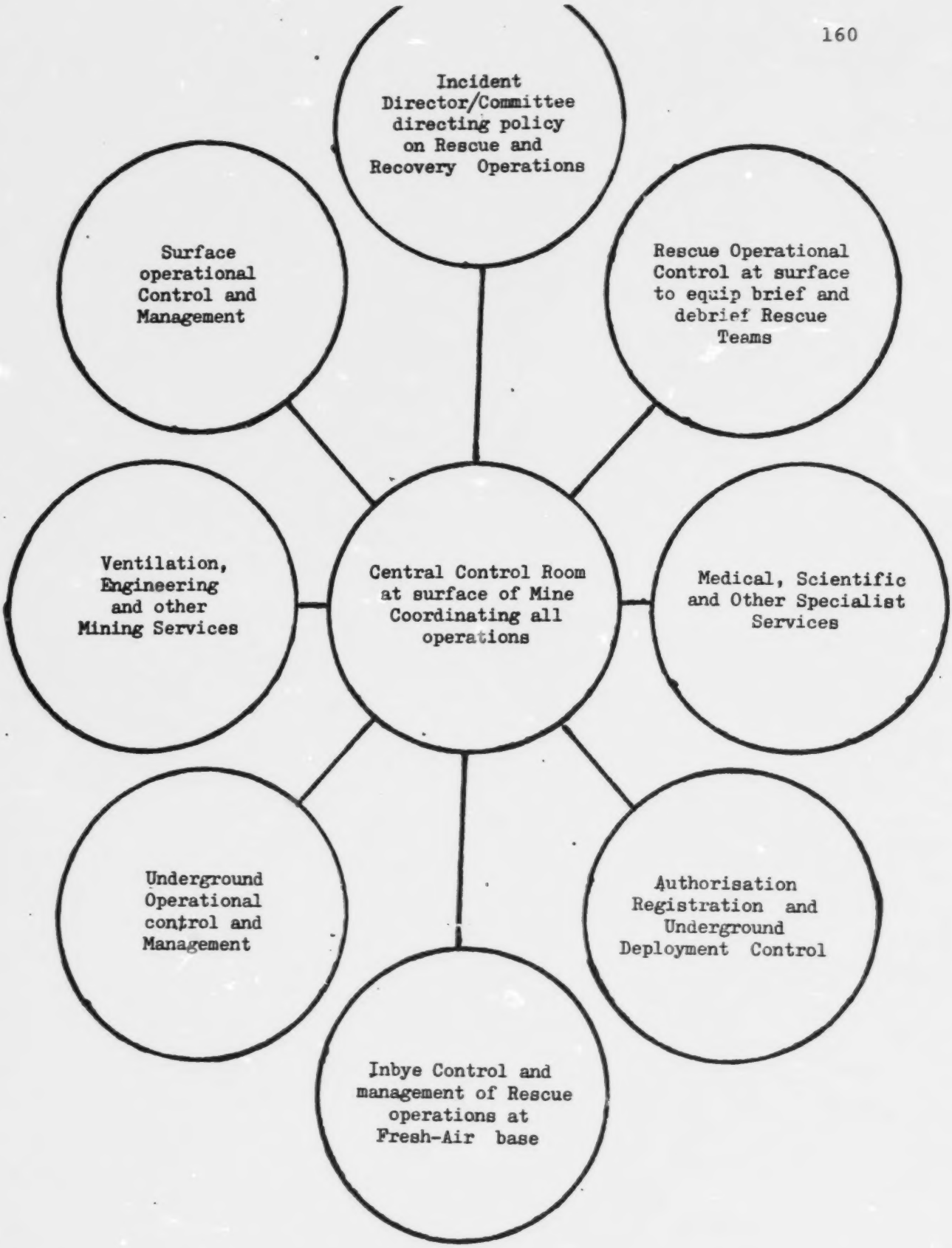
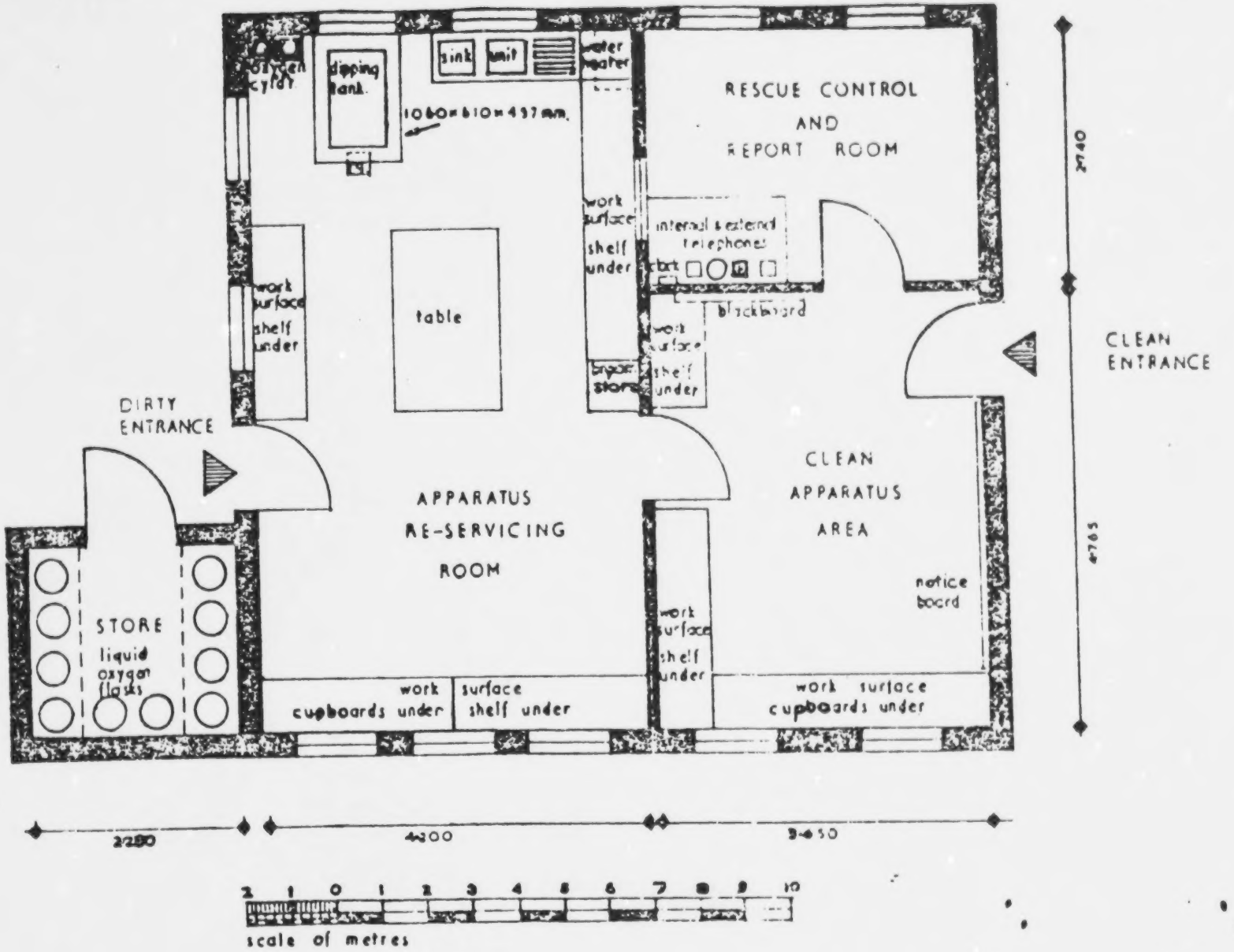

Incident Director/Committee directing policy on Rescue and Recovery Operations
Surface operational Control and Management
Rescue Operational Control at surface to equip brief and debrief Rescue Teams
Ventilation, Engineering and other Mining Services
Central Control Room at surface of Mine Coordinating all operations
Medical, Scientific and Other Specialist Services
Underground Operational control and Management
Authorisation Registration and Underground Deployment Control
Inbye Control and management of Rescue operations at Fresh-Air base

Fig. 3 - Control Arrangements During a Mining Emergency



A TYPICAL COLLIERY RESCUE ROOM.

Fig. 4

DISCUSSION FOLLOWING PRESENTATION OF MR. C. GORRIE

Q. Unrecorded question.

A. I think it is fair to say that the whole purpose of a mine safety legislation is contributory to mine crisis management. I think I would start off from there and say that if there is a real input being made that is the starting point. When a situation arises where it is made quite clear that a hazard has been clearly defined, then some action, of course, has got to be taken to safeguard against that hazard. Whether or not it is voluntary, whether or not the input is mandatory by legislation, it has to come in some way. Our experience with the National Coal Board and with the National Union of Mine Workers in England is that where you can get this done on a voluntary basis, then the results are probably longer lasting. I was speaking about self-rescuers earlier this morning and this is purely voluntary. There is no manditory requirement for self-rescuers in Britain at the moment. Notwithstanding that, every wokman carries one. I don't know that you really could be too dogmatic about people, engineers with skills in crisis management, making too stong a contribution, or insisting that they make a contribution. On the other hand, I think their advice, or rather anyone who ignored their advice, would be rather silly.

RESEARCH PRODUCTS FOR IMPROVED RESPONSE TO MINE EMERGENCIES TO AID MINE MANAGEMENT

BY

R. W. WATSON
Research Supervisor
U.S. Bureau of Mines

Transcribed from tape;
(this presentation was made with the aid of visual slides)

Yesterday, Bob Peluso outlined the roles of MSHA and the Bureau in responding to mine emergencies. It should be pointed out that the Bureau no longer has a legal responsibility to responding to mine emergencies; this is a responsibility of MSHA. Rather the Bureau serves in a consulting role to MSHA and often assist them in providing expertise in mine monitoring, mine communications, etc., and contributes in the area of post-disaster analysis in order to learn the causes of mine disasters. The principle Bureau role is in the development of research products for mine emergencies. This afternoon I would like to review the Bureau's research program in this area. I want to point out that some of the products that I will be describing, are not commercially available at the present time, but many of them are. I will try to indicate which of them are and which aren't. Regardless, there is an abundance of information available on each of the subjects; I would be happy to supply it to you on request.

Slide 1 Research Products for Mine Emergencies.

Slide 2 Coal Dust Explosion in the Bureau's Experimental Mine.

Slide 3 Mine Rescue Exercise at the Experimental Mine.

As you can see, the Bureau has the capability of doing research on full-scale mine fires and explosions.

I have divided my talk into several research categories. The first is:

Slide 4 Protective Equipment

I notice throughout the meeting this week that personal protection in the form of self-contained self-rescuers seem to be a very pupular subject. You all probably know that MSHA has mandated the use of one hour self-rescuers in our coal mines in the United States and that the Bureau assisted in the development of self-rescuers for this purpose. There are now five units approved for underground use. They are:

Slide 5 A Drager unit which is based on a chemical process involving potassium superoxide; it is good for supplying oxygen for one hour.

Slide 6 Another chemical unit developed by Mine Safety Applicance Company in the United States, very similar to the Drager in principle.

Slide 7 There are three approved compressed oxygen units. This is a PASS unit that has a fairly heavy wall aluminum compressed oxygen bottle operating at about 2,000 p.s.i., and again good for one hour.

Slide 8 Also, a unit based on compressed oxygen developed by Ocenco, a light weight fiberglass reinforced aluminum bottle, also good for one hour.

Slide 9 Lastly, a unit being produced by the CSE Corporation in Pittsburgh, Pa; it is a take-off on a unit that was developed in Poland, the AU9, having a one hour capacity; the oxygen is contained in a heavy walled steel bottle.

All of these units have been approved by NIOSH and MSHA for use in underground coal mines. The Bureau has previously investigated the hazard of the chemical units and has recently completed a program on the potential hazards of the compressed oxygen self-rescuers. A report on its findings is in progress.

Slides 10 and 11 The Bureau is also involved in the development of a light weight rescue breathing apparatus. This is an example of one of the units that was developed under a Bureau of Mines contract with MSA. It is a light weight unit with 4 hours duration and is based on compressed oxygen. As shown in the next slide, the compressed oxygen is contained in a bottle basically the same but larger than that used in the Ocenco unit: A thin walled, fiberglassed re-enforced aluminum bottle.

Slide 12 We also have under development a mine rescue team helmet that provides illumination and communications capability as well as life support. It is being developed by the Gentex Corporation and has elicited a fair amount of interest from other agencies including our Air Force.

Slide 13 A new programable metabolic simulator used for testing the life support functions of self-rescuers is also under development. It is shown here connected to a Drager self-contained self-rescuer. It will be used in the development of criteria for the approval of slef-rescuers.

Another research area is monitoring:

Slide 14 Monitoring.

Slide 15 In the area of monitoring, we have developed mine fire gas analyzers of the type shown here. This is a gas chromatograph and is capable of making precise measurements of CO, oxygen, carbon dioxide, hydrogen, methane, and total combustibles. The unit on the left is a gas chromatograph. The central unit is a read-out unit that can give alarm at pre-determined levels for each of these gases. The unit on the right is the power supply and also the gas supply for operating the valves in the chromatograph.

Slide 16 We have also developed a series of portable gas detectors of the type shown here. These are battery powered, light weight units, each weighing about a pound and a half, approved for use in underground coal mines. The blue unit is a carbon monoxide unit that is applicable in the range of 1 to 1000 parts per million. It is commercially available. The orange unit is a nitrious oxide unit

again having the capability of making measurements over the 1 to 1000 parts per million range. The brown unit is a nitrogen dioxide unit for measurements in the range of 1/10 to 100 parts per million. All three units are based on the fuel cell principle and are being manufactured by General Electric Corporation.

Slide 17 We also have developed under contract with Andros a high concentration methane detector. It has two ranges, 0 to 5 percent and 0 to 20 percent. It utilized the principle of non-dispersive infrared absorbtion in a pressure modulated gas cell, and should be applicable to many mine emergency situations where high concentrations of methane are detected, especially in low - oxygen environments.

Slides 18, 19 and 20 We also have developed a fairly unique smoke detector; the sophisticated name for this is a sub-micron particulate detector. It is based on an ionization principle and utilizes a low level source of Americium 241 to activate the unit. It has digital readout and basically measures the concentration of smoke particles in air and also has particle size discriminating capability. It is useful as a sensitive fire detector and particularly so in determining the status of sealed mine fires. Also, it can be used in the detection of re-ignitions during the recovery of sealed mine fires and the evaluation of the effectiveness of fire extinguishing and control techniques. The chief advantage of the unit is shown in the next slide, where we see the results of a sealed mine fire experiment conducted at Bruceton. If you look at the rise and growth in the carbon monoxide level as a function of time, you will see that the gas concentration reaches a particular level and sort of saturates at that level, and you have to depend upon small changes in that level to determine what is happening in the fire.

The particulate detector, however, has the unique capability associated with the fact that the smoke particles have a tendency to follow the temperature of the fire very closely. If the fire temperature drops to below the ignition point, the smoke particles are no longer generated and they gravitate out and reduce the number of particles per unit volume in the measured volume. This is the principle application and we have applied it to a fair number of actual mine fires over the past several months.

Slide 21 We are also doing some more fundamental work on explosion diagnostics in creating a library of scanning electron micrographs of coal particles that have been exposed to various temperature histories. As shown here the original particles have fairly sharp edges but when exposed to elevated temperatures develop a characteristic blow-hole pattern. This pattern can be related to the temperatures the particle has seen. This technique was particularly useful in the Dutch Creek Mine disaster investigation where we were able to identify a possible ignition source.

Slide 22 Communications.

Slides 23, 24, 25 and 26 Yesterday, Bob Peluso showed you the seismic location capability of MSHA's Mine Emergency Operation. Basically the system depends on the generation of a seismic signal by a trapped miner, the propogation of the signal through the earth and the detection of the signal by geophones at the surface. Computer triangulation of signals from several detectors is then used to pinpoint the exact location of the trapped miner.

Slides 27 thru 33 The Bureau is also developing a new system based on electromagnetic propogation. It is a voice frequency system that operates from a transeiver that can be located in a miner's cap lamp battery, for example. In use, an antena is deployed underground and voice frequency signals are then propagated through the earth and detected by helicopter and localized more precisely by surface measurements. Once the source is localized, a high powered communication system is then set up for direct voice communications with the trapped miners.

Slides 34 thru 40 We are also working on medium frequency communication systems involving frequencies around 300 kilohertz. This is a coupled unit that depends upon the existence of conductors within the mine to transmit the signal out of the mine along the conductor which is detected at the surface enabling communications with trapped miners. If no conductors are available, a probe can be inserted through a bore hole and short range communications can be established by direct line with the medium frequency signals. A typical application is in mine rescue team operations. We also have developed a hoist communication system, also medium frequency. It depends upon coupling and RF signal to the hoist rope, which is then used to communicate the signal to the underground workings. This is a complete unit, receiver and transeiver for propogating and receiving signals in this fashion.

Slides 41 and 42 Bob Peluso also showed you some of the bore hole probes that were developed by the Bureau and are now being used in the Mine Emergency Operations at Hopewell - television cameras, gas analytical equipment, and communication links with underground can be operated through bore holes.

Slide 43 Escape.

Slides 44 thru 48 In the area of escape, the Bureau is doing some fundamental work on the physiological response of coal miners to mine emergency situations; it is being conducted under a contract with Penn. State University. We have developed a series of portable, explosion proof refuge chambers of the type shown here. This is a refuge chamber that can be installed in a very short time and is capable of withstanding explosion pressures of the order of 20 p.s.i. A more permanent bulkhead that will withstand much higher pressure is the sandbag bulkhead that can be used for emergency chambers underground. A more complex version is shown in the next slide, which is built out of re-enforced concrete block. Another system shown in the next slide, is basically a cement block-sand composite that can withstand pressures up to 60 p.s.i.

Slide 49 Ventilation Modeling

Slides 50 thru 56 We have also done research on computerated ventilation modeling. This work stemmed from developments on Professor Grurer at Michigan Technological University and has received quite wide-spread application. It depends upon basic input data from mine fire scenarios; for example, the heat source can be oxygen rich or fuel rich. It also treats transient heat loss problems. It has applications in predicting critical airway or critical escape paths for trapped miners. You can arbitrarily set criteria, for example, the temperature, smoke concentration, methane concentration that you demand for a safe escape way and the computer program will predict those safe escape routes from a growing fire situation. Basically, the program uses the conservation of mass and conservation of energy and the complex mine geometry and is able to give you real time predictions, the spread of fumes and in this case for an oxygen rich fire.

Illustrated in the next series of slides is a fire source shown in a fairly complex mine geometry. The start of the spread of fumes at ten minutes and then at later times, 20 minutes, showing the further progress of the fumes and finally the fume spread throughout the entire mine geometry. This computer code is applicable to a fairly wide range of mine problems and has been used to determine the proper approaches for ventilating sealed mines where the methane concentration is high enough to be worrisome. It has been experimently validated recently by some measurements at our Lake Lynn Laboratory, which has added some creditability to the computer code.

Slide 57 Recovery

Slides 58 thru 61 For controlling ventilation during recovery operations, the Bureau has developed a compact self-sealing brattice which weighs about 10 to 15 lbs. It can be installed very quickly, of the order of 10 to 15 minutes using studs, ramsets or jackpales as shown here. This shows an installation at our Experimental Mine which was completed in less than 15 minutes. The brattice is applicable to fairly low pressure situations: differential pressures of the order of 5/100 of an inch of water.

Slides 62 thru 67 Another tool for mine emergency response is a remote mine sealing technique that starts with a probing of the area to be sealed with the bore hole camera that was shown previously. The selected area is then sealed by the injection of fly ash and the seal is consolidated by a foam topping.

Slides 68 thru 71 The subject of mine inerting ... fire fighting by nitrogen injection or by means of an inert gas generator has been discussed earlier in the meeting. Dr. Kryzstolik gave a brief description of the Polish Inert Gas Generator which is shown here. It is capable of delivering 25,000 to 50,000 cfm of inert gas containing 1 percent or less oxygen. The unit has been successfully applied in Europe in fighting some very severe mine fires. We recently demonstrated the capability of the inert gas generator through a contract with CSE Corporation of Pittsburgh. A unit, along with 10 engineers was brought over from Poland and applied to some deep seated coal fires in our Experimental Mine at Bruceton. It easily extinguished the

experimental fires but as yet has seen no application to real life fires in the U.S.

Slide 72 Personnel Training.

Slides 73 thru 75 In the area of personnel training, the Code of Federal Regulations Part 49 calls for training for mine rescue teams, and the Bureau has developed a fairly comprehensive program consisting of packages of training aids that can be used for classroom purposes, as shown here. The training packages cover subjects like first aid, self-rescuers, respiratory devices, surface organization, mine gases, mine ventilation, exploration, fires, fire fighting, explosions, rescue of survivors and recovery of bodies and mine recovery. The entire package is available either at West Virginia University or at the Mining Academy at Beckley, West Virginia.

That, gentlemen, is a brief outline of what we are doing, I would be happy to answer any questions that you may have.

USEFULNESS OF EXPERIENCE FROM EMERGENCY SITUATIONS AND EXERCISES FOR THE WORK OF MINE RESCUE TEAMS

BY

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USEFULNESS OF EXPERIENCE FROM EMERGENCY SITUATIONS AND EXERCISES FOR WORK OF MINE RESCUE TEAMS

1. HARD COAL MINING IN THE RUHR COALFIELD

Fig. 1

In 1981, the Federal Republic of Germany produced 88 million tons of saleable hard coal of which 72 million tons came from the Ruhr and the Ibbenbueren coalfields. The Mine Rescue Centre in Essen is responsible for these two coalfields including 28 mines plus 1 rock salt mine. The total underground work force employed is 90,000 miners. The coal stems from 183 faces producing daily 1500 t as an average. The average-sized mine with a daily saleable output of 10,000 t (mean dirt percentage 45%) thus has 6 or 7 operative coal faces. The performance per manshift is about 4 t. The average mining depth comes to almost 900 m and the mean coalbed thickness worked to 1.80 m. The normal methane emission is 10 m^3 per ton of coal extracted, with peak emissions as high as 90 m^3.

2. MINE RESCUE CENTRE IN ESSEN

Fig. 2

The Mine Rescue Centre in Essen was founded in 1910 by the mining companies of the Lower Rhenish-Westphalian coalfield. Today the Centre is a department of Bergbau-Forschung GmbH, the research establishment of Steinkohlenbergbauverein.

The main duty of the Centre is the improvement and management of mine rescue services. Changes in the structure and technology of the coal industry brought about a stepwise enlargement of its original duties.

3. MINE RESCUE TEAMS

The establishment of a mine rescue team at each coal mine has been imposed by the mining authorities. Membership to a rescue team is voluntary. In the Ruhr coalfield there are 36 mine rescue teams ready for action totalling some 3000 members or 3.3% of underground work forces.

Each mine rescue team -- of normally 80 members -- is headed by an overman who, considering emergency requirements, is assisted by at least three deputies. Each team comprises at least 10 groups consisting of a group leader and four group members. There are about 3000 apparatus attendants to keep the extensive equipment -- among other 1600 circuit apparatuses with 400 l of oxygen reserve -- in working order. 75% of the team members are equipped with ultra-short wave alarm receivers. On an average 15 minutes will elapse between an alarm and readiness for action, which means that at any moment two mine rescue groups or ten people can be set to work, fully equipped, in less than 30 minutes.

The overman is supported by engineers of the Mine Rescue Centre to help him in his complex duties. In cases of mine accidents they accompany the rescue teams to the underground to contribute their expert advice and practical help. Within the emergency management at the surface their expert competence will essentially bear on the course of any rescue action.

4. MINE RESCUE TEAM ACTIONS AND FIRECONTROL

The mine rescue team intervenes after explosions as well as in case of mine fires and other events where hazards may occur due to
Fig. 3 noxious gases or lack of oxygen. Rescue teams within the area of the Essen mine rescue centre had to intervene 838 times during the past 20 years, which means 42 times per year as an average. In recent years, mine fires due to spontaneous combustion became less frequent. The present mine fire index is 0.1 fires per million tons of annual coal output. Bigger open mine fires did almost not occur any longer, this thanks to massive efforts to improve fire protection. The transformation of self-extinguishing fabric conveyor belts which had started in 1975, was completed last year. The proportion of steel-reinforced conveyor belts of identical properties amounts to some 50%. Timber consumption in mines, having been of 21 solid cubic meters per 1000 tons of saleable coal output 20 years ago, has been cut back to 5 m^3. The use of hydraulically setting construction materials has increased to about 1 million tons per year, i.e. doubled, between 1977 and today. Roadside stoppings are the general standard of any modern face. They have in many instances proved their usefulness as a prerequisite for effective suppression of spontaneous combustion in the goaf. Premature warning of underground work forces is ensured by a dense network of CO recorders (more than 1100) and of modern communication systems. 21 of our mines use processors for a premature identification of mine fires.

5. FIREFIGHTING BY MEANS OF NITROGEN

It was in December, 1974, when for the first time in West German hard coal mining liquid nitrogen was evaporated at the surface and
Fig. 4 introduced, at a rate of approximately 60 m^3/min, to an underground fire zone. Thence developed a standard procedure of mine firefighting, -- procedure which was applied in 58 emergencies through 1981. With a nitrogen consumption of some 165 million m^3 it allowed to save 50 face equipments plus a daily output volume of approximately 50,000 t.

The objective of mine fire inertization is to reduce the oxygen
Fig. 5 content of the mine air and thus avoid explosion hazards as well as to restrict the fire extension and intensity. To make a methane/air mix inexplosible one has to bring its oxygen content down to less than 12% by volume. This is also sufficient for an open flame fire to extinguish. To fight spontaneous combustion fires successfully the oxygen content has to be diluted to less than 3%. Moreover, the interventions in warm underground pits the supply of cold and dry nitrogen alleviates the working conditions for rescue men. And, in particular cases, explosible methane/air mixes can be safely flushed out by nitrogen. The latter procedure was applied after an explosion in the underground of the Hansa hydromine in 1979.

Fig. 6 For inertization of a fire zone one starts by filling with nitrogen a zone which has been isolated on at least one side. The procedure is applied predominately for fighting open fires or, in case of deep-seated fires, for eliminating explosion hazards in the caving area.

Fig. 7 For object inertization the seat of a fire is directly flooded with nitrogen. This serves to replace the stray ventilation current supporting a deep-seated fire as completely as possible by inert gas. The nitrogen volume flow requirement will normally be lower than for inertization of a fire zone.

A deep-seated fire will almost never be definitely extinguished by the introduction of nitrogen. Thus conventional sealing is still necessary. Even with an open mine fire direct firefighting and cooling will have to be applied starting already during the inertization procedure.

The inertization has invalidated the previously clear distinction between sealing-off and reopening of fire zones. Nowadays there is a gradual transition between the two phases. Time-saving may, when an underground area is to be recovered, be of vital importance to a mine.

Fig. 8 A long and auxiliary-ventilated roadway which in 1982, after gas ignition with ensuing fire, had to be isolated initially at the starting point of the auxiliary ventilation, could be recovered section-wise thanks to the introduction of nitrogen and notwithstanding difficult conditions of climate. To the effect the mine rescue team erected five temporary mine air seals spaced at still acceptable distances os that after flushing of each section the starting point for erecting the next seal could be advanced.

Thanks to steady progress in technology, organization, and logistics it is possible, nowadays, to apply the procedure anywhere in our coalfield within less than twelve hours.

6. SCHEME OF RESCUE ACTION

Explosions, mine fires, roof breaks in coal faces and roadways, water inrushes, and similar events, require concertated and immediate efforts in order to rescue the miners affected. The entire package of organizational and technical actions to be taken in these emergencies are laid down in a relevant scheme. It is basically followed also for any other major interventions by mine rescue teams.

The scheme settles among other things:

- warning of the persons to be involved in the rescue action;
- immediate actions to be taken by the temporary head of the emergency management;
- duties of the emergency management;
- the duties of the other persons involved.

7. Responsibility for Rescue Actions

As of January 1, 1982, has become effective a new Federal Mines Act according to which the operator of a mine or the responsible persons entrusted by him have to take any measures apt to eliminate hazards or to rescue victims. This means that the Mines Inspectorate will no longer be the sole responsible for managing rescue actions although it may -- as the case may be -- direct the necessary measures.

8. ALARM SCHEME

The warning centre receives instruction to give alarm either from the mine management or from the supervisor on charge. In an extreme case any miner telephoning directly from the endangered zone may initiat the warning procedure. The advantages of ultra-short wave radio systems have proved to be valuable, indeed, for warning mine rescue team members. We therefore scaled the system up to create an emergency radio communication system for the mining industry which allows to warn a larger number of persons.

9. MANAGEMENT OF RESCUE ACTIONS

Fig. 9 Until formation of the management for mine rescue actions, the temporary head of the emergency management initiates any instantaneous measures required. The mines maintain a permanent stand-by service for the persons concerned. The temporary head of the emergency management is not allowed to go underground in case of alarm.

Independent of any legal considerations any and all actions are directed by a work team called management of rescue actions or emergency management. Representatives of the mining authorities, mine management, and Mine Rescue Centre closely cooperate in this management. If the latter is to function efficiently one should make sure that the group which theoretically consists of three men be by no means enlarged beyond a very restricted basis. The duties of the management are summarized in a check-list by subject matters. For major mine accidents the establishment of an information office has proven its usefulness. It is here where all the persons arriving later are supplied with preliminary information on the status of rescue actions. Associated to the emergency management is the necessary assisting staff which prepares decisions and pursues directed measures through to their completion. Any and all arriving reportings and outgoing instructions are noted down at the emergency management. The relevant minutes serve, among other, as a reference document for eventual investigations and evaluations. The minutes are meant, however, above all as a memo and should preferably be broken down by working units. The keeper of the minutes is to remind the management of actions due to be taken; he is supposed to cooperate actively instead of just writing.

10. COMMUNICATION SYSTEMS USED BY THE EMERGENCY MANAGEMENT

Fig. 10

The emergency management can function well only if all the information required is made available and if it is able to rapidly contact any agency concerned. Therefore an appropriate location has been provided and equipped with suitable means of communication among which: a two-way telphone system, a telephone where only calls from the underground can be received, a "red" telephone whose number is not made known, and a normal telephone set. There may be provided furthermore a monitor with plotter permitting to directly transmit and scan any desired measuring values from the control room. If nitrogen is used for firefighting and conditions are difficult, it is possible to transmit for instance pressure, temperature, and volume flow (sometimes these parameters may be remotely controlled).

In any case, a special telephone line or radio language communication has to be installed between the inert gas plant and the emergency management.

11. SCHEME OF MUTUAL ASSISTANCE

Fig. 11

Notwithstanding the size and efficiency of our mine rescue teams it became obvious that major emergency situations can only be handled with the assistance of neighbouring teams. According to a scheme of mutual assistance, therefore, every mine may request four other teams to come and help. When several rescue teams are simultaneously active at one site, the emergency management will define and delimit the duties and responsibilities of each overman.

12. FRESH-AIR BASE

Fig. 12

During the first intervention of the mine rescue team a stand-by group stays behind at a "temporary fresh-air base" being in telephone communication with the emergency management. As soon as possible upon consultation with the emergency management one or more fresh-air base should be as near as possible to the site of intervention and, on the other hand, be at a safe distance from it. The overman supervises the fresh-air base. He reports directly to the emergency management. The first intervention normally serves for exploration and, thus, falls under the concept of "aggravated conditions". By aggravated conditions are understood underground workings where humid and warm air, seriously reduced visibility, and sections difficult to travel through prevail. In these circumstances the members of stand-by groups, with oxygen breathing apparatuses worn on their backs, stay as close to the site of intervention as is possible without using the apparatus. This means that normally each fresh-air base is manned by three rescue groups.

13. DURATION OF RESCUE ACTIONS IN HUMID AND WARM MINE AIR

Fi 13 Due to depth and degradation of climate by the fire, the normal two hours of action often cannot be held out. At temperatures of e.g. t_d = 36° C and t_w = 32° C the intervention is reduced to one hour. Then four groups are required to permanently man the site. If temperature reach t_d = 43° C and t_w = 38° C, the action has to be reduced to as little as 20 minutes. In this case one even needs nine groups if gaps are to be avoided. Now, how many oxygen breathing apparatuses will be required for the groups in each of these three constellations? For three groups are required 17, for four groups 22, and for nine groups 32 apparatuses. In any case 12 oxygen breathing apparatuses remain at the surface rescue station. If the internal reserves of apparatuses are inadequate to maintain this number, additional units would be requested from one of the assisting neighbouring rescue teams.

14. EQUIPMENT FOR A FIRST EMERGENCY INTERVENTION

Fig. 14 A good starting position for rapid first interventions has been created by keeping the equipment of the rescue teams ready in easily transportable dragging baskets at the mine rescue station. This basic equipment is only for first explosation and will be supplemented whenever firefighting or rescuing of men is directed. It is only when further groups are starting out for action that the material which is also kept ready for easy transportation to the fresh-air base, will be brought to the underground.

15. TELEPHONE SYSTEMS FOR RESCUE SQUADS

Fig. 15 Efficient information and communication between the advancing group and the fresh-air base is of critical importance to the safety of a rescue team. Here, intrinsically safe, sound powered telephone
Fig. 16 systems proved their usefulness. Language communication is amplified in both directions by using a loudspeaker. The stand-by group, thus, gets detailed information on its duties ahead. For first interventions the advancing group carries one or more line cartridges (weighing 2.6 kg of 400 m length each which are fastened to the belt and unroll
Fig. 17 automatically. After the first intervention this delicate thin line will be replaced by a more robust flat-strand line equipped with interception pinches. Using these pinches the rescue group is able to "tap" the telephone line at any point between the site of intervention and the fresh-air base. The loudspeaker is of a portable type (weight 7 kg) and is taken along to the site also for stationary work.
Fig. 18 Trials on radio sets for language communication indicate that such system may also be of use for some aspects of mine rescue actions. On the other hand it is impossible to replace the present mine rescue telephone systems I and II completely by radio systems, at least for the time being. And it has been demonstrated in many instances that one should by no means renounce at such valuable means of perceiving als all the side-noises, even breathing noises of the telephone mask user. In some rescue actions where visibility was severely reduced the telephone line really was a kind of Ariadne's thread and helped the rescue group to get out again.

16. OXYGEN SELF-RESCUERS

Fig. 19

Every rescue group takes along at least one oxygen self-rescuer. When men have to be rescued oxygen self-rescuers may also serve them provided that the persons concerned are still capable of breathing by themselves. Mine rescue teams have been equipped for many years now with OXY-SR 45 oxygen self-rescuers by Draeger. One of these days will commence delivery some 400 oxygen self-rescuers of type AUER-SSR 120 (size category K 90) which are to be fullscale-tested both in normal and in mine rescue conditions.

As is known, for the first time in 1951 all the miners of one colliery in the Ruhr coalfield were equipped with filter self-rescuers. Until 1981 more than 6500 filter self-rescuers were used in 509 escape situations. 25% or some 1600 miners were highly probably saved from serious to fatal CO intoxication. Nowadays all the mines are equipped with such devices whose service duration safely covers the maximum admissible escaping time of 90 minutes. For the sake of a uniform escape scheme are being tested, therefore, exclusively oxygen self-rescuers for a minimum duration of 90 minutes (tidal volume of 35 l/min). It is intended to introduce them:

- in unusually long auxiliary-ventilated roadways;
- in auxiliary-ventilated roadways where Diesel-powered, rubber-tyred vehicles are used; and
- in workings prone to gas eruptions.

The new oxygen self-rescuers of extended service duration are to be used also as auxiliary devices for mine rescue teams as well as for rescuing of men and should in the long run replace devices of shorter duration.

17. FLAME-RESISTANT GARMENTS

Fig. 20

In the case of one underground explosion back in 1965, it turned out that five members of a rescue team were fatally burnt although they wore regular flame-resistant garments. Prompted by these fatalities a procedure was developed allowing the direct assessment of heat effects on man. Several years ago improved flame-resistant garments were introduced whose protective effect is about twice as high as of previous fabrics. The outfit consists of underwear of a voluminous sprongy fabric (495 $g/m/^2$) and of a double-layer suit made from Nomex III (2 times 265 g/m^2) of antistatic properties. The flame-resistant suit is nowadays also worn as the normal working outfit of rescue team members. When explosion hazards prevail, protective hoods and gloves are worn as well.

18. MANUAL MEASURING DEVICES

Gas measuring techniques have gained increasing importance for
Fig. 21 the work of rescue teams. Not at least for their non-interference with ongoing inertization operations are in use, besides manual oxygen measuring devices, exclusively those types of manual and portable measuring instruments whose indications remain unaffected by lack of oxygen or whose cross sensitivity is easy to assess.

19. PHYSICAL PERSEVERANCE

Modern life style and the obsoleteness of physically exerting labour have resulted in a general restriction of physical mobility. This, in turn, leads to a reduced capacity of physical perseverance. The phenomenon is by no means specific to the mining industry nor typical for rescue team members but, unfortunately, applies also to them. We observed that rescue team members during their work -- and specifically when travelling through inclined workings -- as well as during their exercises showed increasing signs of physical deficiency.

In 1978 we, therefore, determined the perseverance characteristics
Fig. 22 of 300 rescue team members by subjecting them to exercises on the ergometer bicycle. An inadequately trained physical condition was observed with 14% of the men! 42% only of the persons examined showed good or even excellent physical perseverance. The physical deficiencies stated will in an emergency situation not only endanger the individual in question but also the other group members. We, therefore, introduced four remedial measures.

20. EXAMINATIONS BY THE SERVICES OF OCCUPATIONAL MEDICINE

The regular ergometric examinations in the framework of check-ups
Fig. 23 by the services of occupational medicine are now carried out according to a uniform method. To the effect the rescue team members are subjected to maximum loads depending on their age and weight, i.e. the desirable heart frequency should be 200, minus age. Here, a physical performance should be achieved equalling three times the weight. If training is inadequate the persons are suggested a purposeful perseverance training.

21. EXERCISES AT SURFACE FACILITIES, INCLUDING PERSEVERANCE EXERCISES

The two hours of surface exercises were completed by a
Fig. 23 "perseverance" section which is focussed on the aspects force training, travelling, working, and includes a perseverance training of 15 minutes. For perseverance training are used the bicycles. The load, starting with 1.2 W times kg of body weight, is increased by two increments of 20 W each (sub-maximum load).

22. CHECKING OF PHYSICAL CONDITION

Fig. 24 The same ergometer bicycle is used for checking the physical condition of the men, with monitoring of pulse frequency. The result is displayed as a characteristic value and plotted on a perseverance chart. This checking is also done at sub-maximum load. If a person shows physical deficiencies the overman will, as the case may be, have him examined by the services of occupational medicine.

23. TRAINING

Fig. 26 There are several kinds of activities apt to build up and maintain physical endurance. To the effect we established training suggestions containing practical instructions as to the frequency, intensity, and duration to be observed. We have not been successful so far in convincing all of the rescue team members of the necessity of a purposeful perseverance training. But nevertheless a major proportion of them accepted to do running exercises. Mine rescue teams promote this type of activity by arranging special running competitions where so far up to 500 rescue team members attended at one time. Some of the men also started to practice the fitness training recommended by the Royal Canadian Air Force. As a result of a pilot study by Ruhrkohle AG has been suggested to install locations equipped with isokinetic training devices. It had been demonstrated by a training program that not only the muscular condition and blood circulation but also motorial efficiency improved within a few weeks. Several collieries will provide such training rooms.

24. MANRIDING FACILITIES IN MINE RESCUING

Fig. 27 As a consequence of lay-outs in horizon mining, concentration of several collieries in compounds, connection of new mine takes to existing collieries, and widely expanding introduction of belt conveying means, mine rescue teams were faced many times with difficult to solve problems. When doing exercises in inclined drifts it became obvious that rescue men, even in a perfect physical condition cannot do without mechanical manriding facilities. All technical and organizational potentials should there, be utilized to make available manriding facilities in good working order also in cases of mine fires or explosions In several instances operator stands or drives were either transferred Fig. 28 to the intake air side or designed in a way that they can continue operating also in emergency situations. In long roadways with auxiliary ventilation rail bicycles are kept ready either for escape purposes or for advancing rescue groups. Battery-powered floor-bound transport means and suspended monorail trains lend themselves to rescue actions very well in so far as they can continue operating also in case of lacking oxygen. This advantage is felt particularly during inertization. Technical potentials in this field are, however, far from being fully utilized. Any future improvement should, more intensively than so far, be sought under the aspect of making escapes safer and improving mine rescue services.

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Abb. 1

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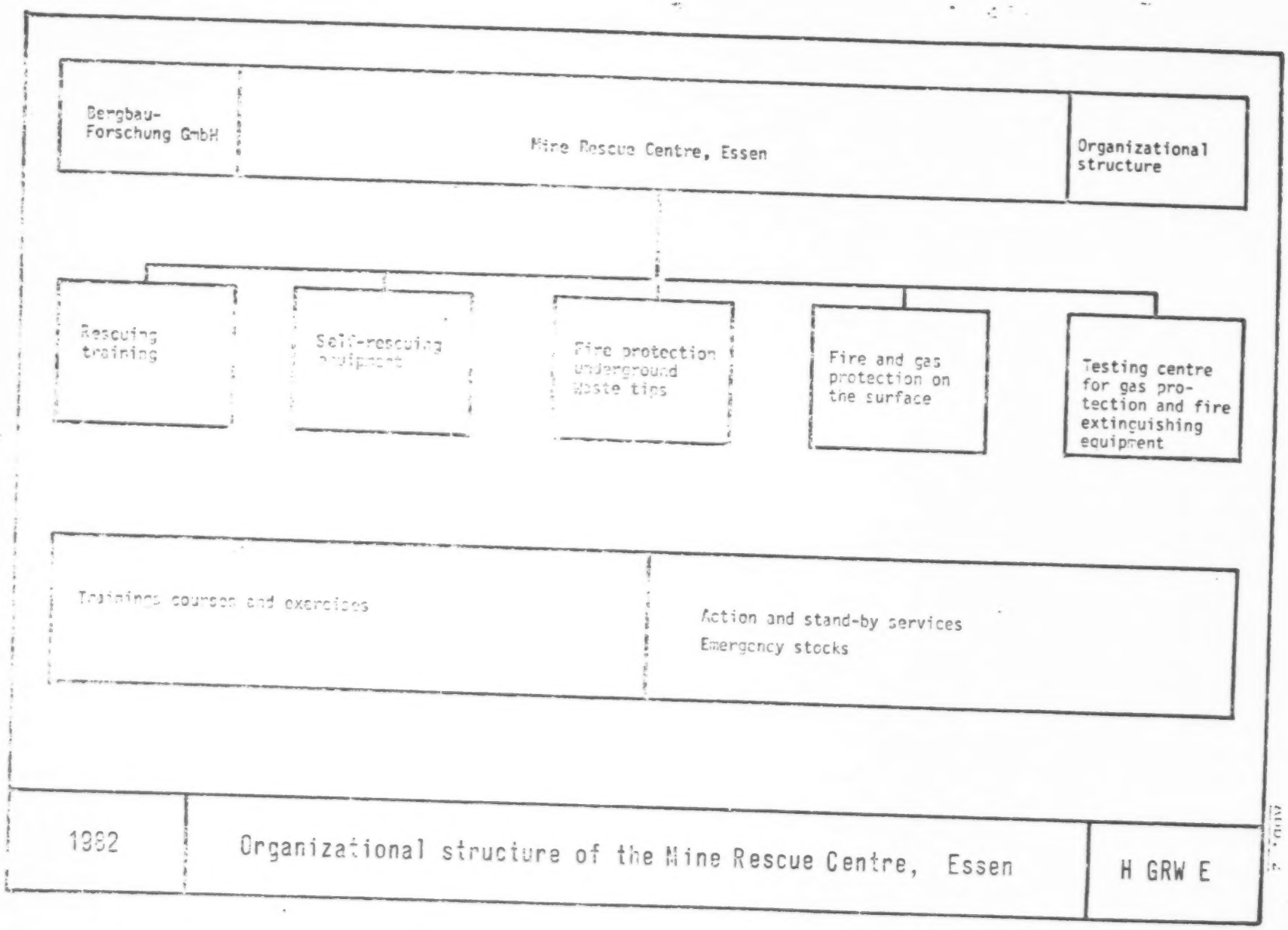
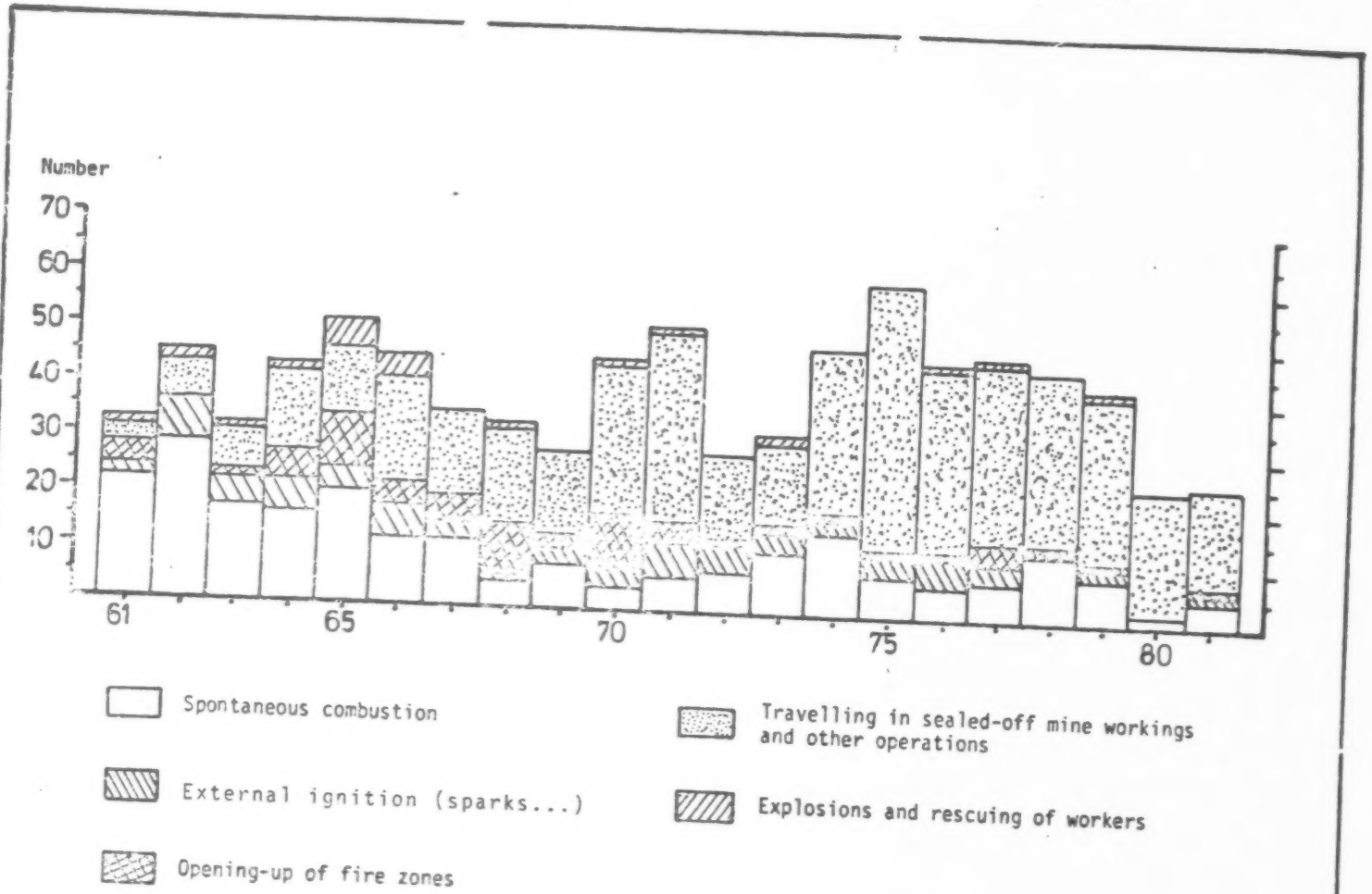
Köln
Aachen
Frankfurt
Heidelberg
Saar-
brücken
Stuttgart
München
1982
Coal-measures
in the Federal Republic of Germany
HGRWE


Bergbau-Forschung GmbH
Mine Rescue Centre, Essen
Organizational structure
Rescuing training
Self-rescuing equipment
Fire protection underground Waste tips
Fire and gas protection on the surface
Testing centre for gas protection and fire extinguishing equipment
Trainings courses and exercises
Action and stand-by services
Emergency stocks
1982
Organizational structure of the Mine Rescue Centre, Essen
H GRW E



1982 | Number of mine rescue operations 1961-81 | HGRWE

Abb. 3

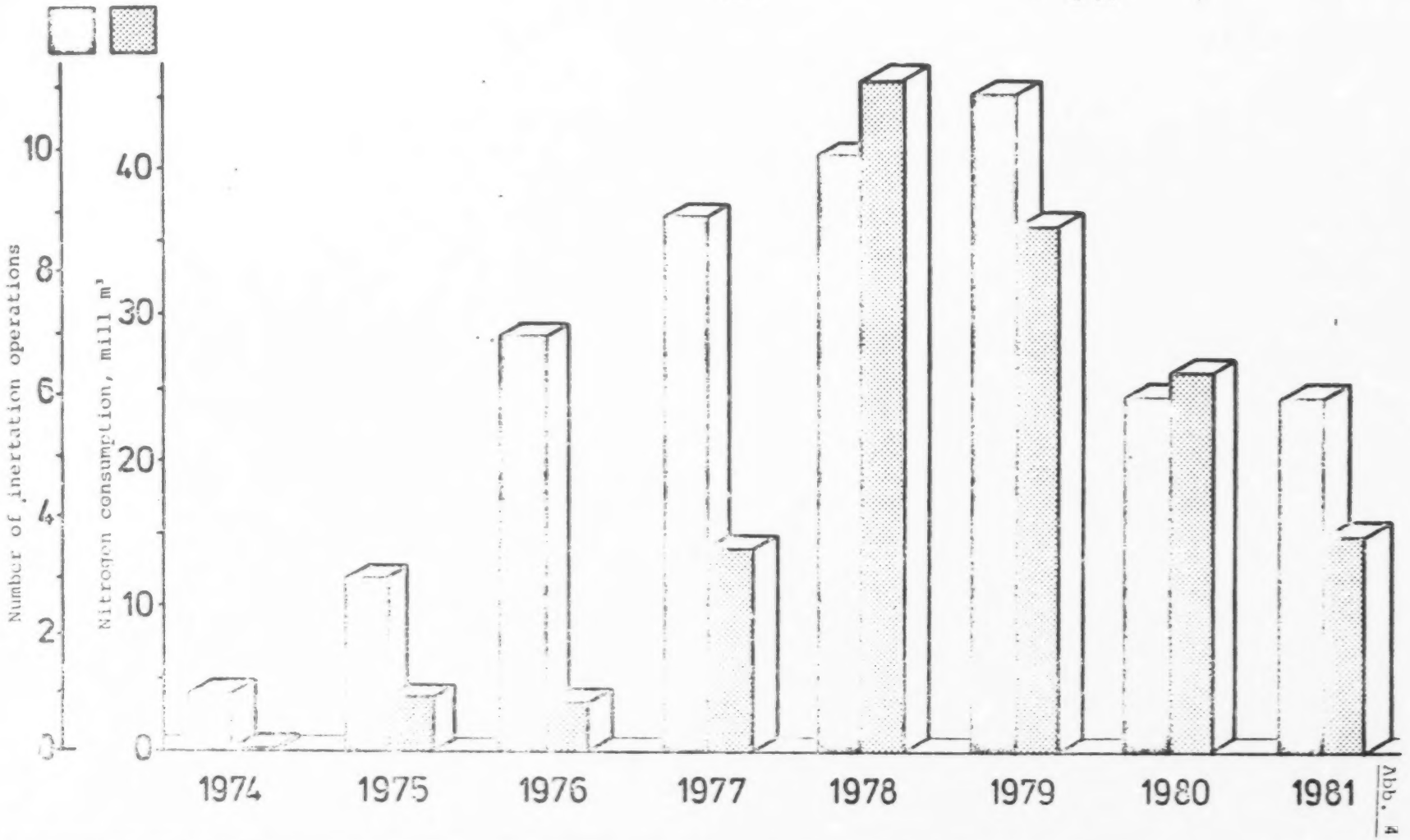


Abb. 4

1982	Number of inertation operations and nitrogen consumption	HGRWE

/RT

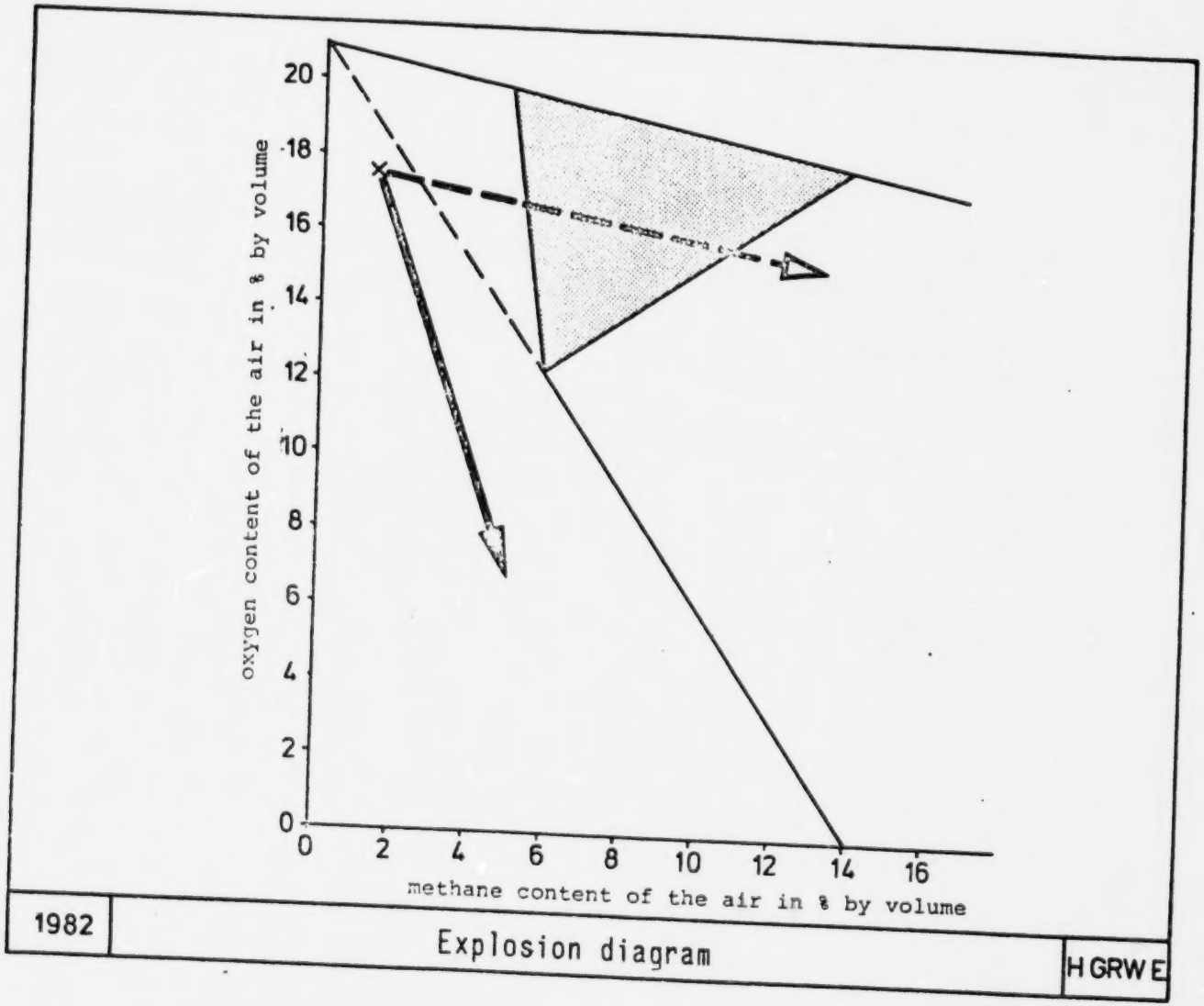

oxygen content of the air in % by volume
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
methane content of the air in % by volume
1982
Explosion diagram
HGRWE

Abb. 5

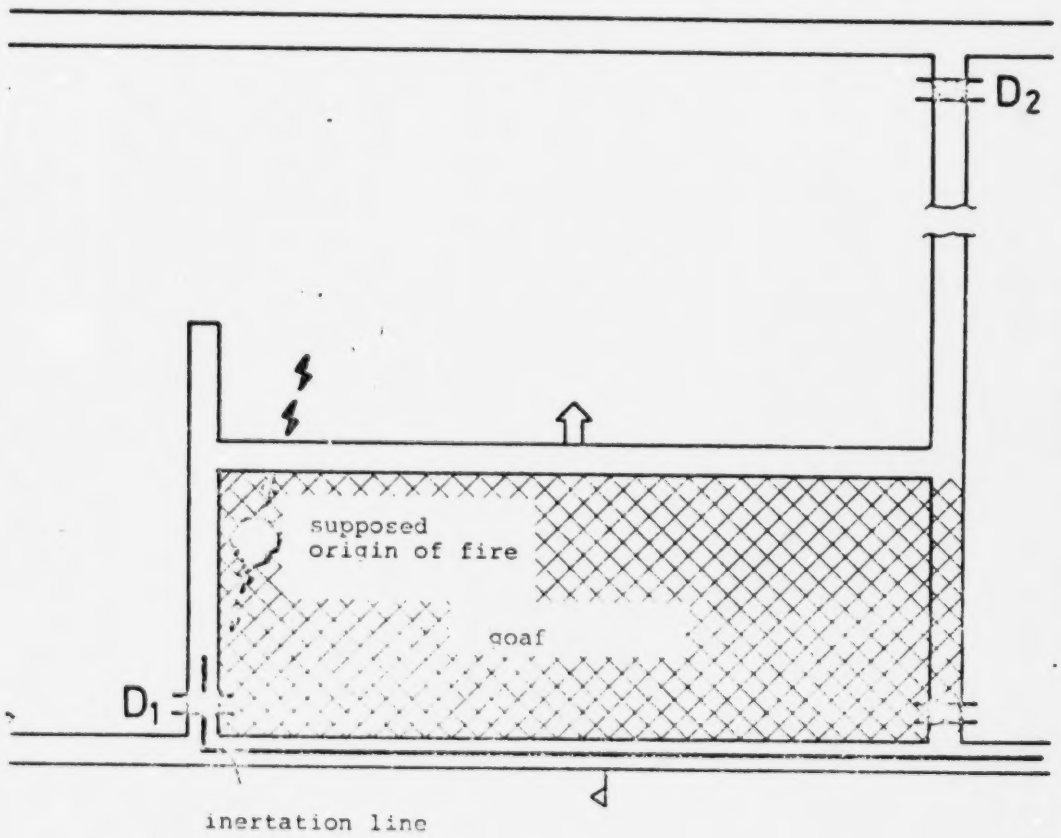


Abb. 6

1982	Sealing-off and inertation of workings	H GRW E

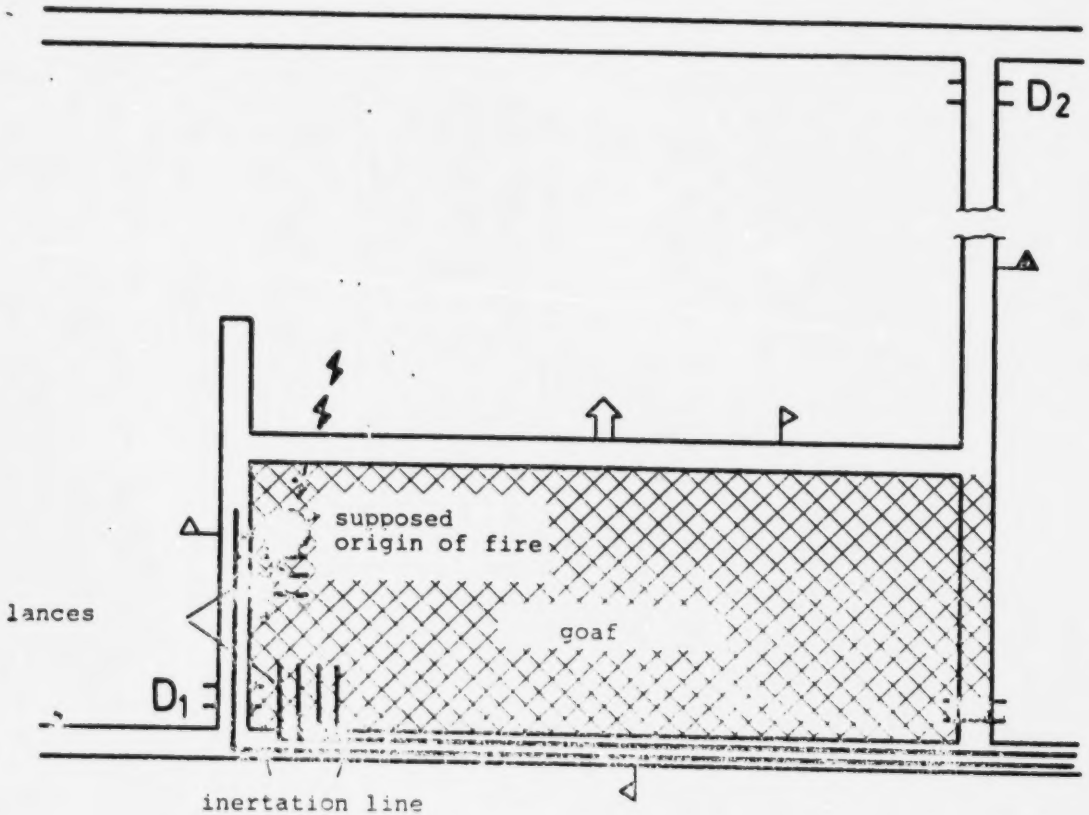


Abb. 7

1982	Inertation of objects	HGRW E

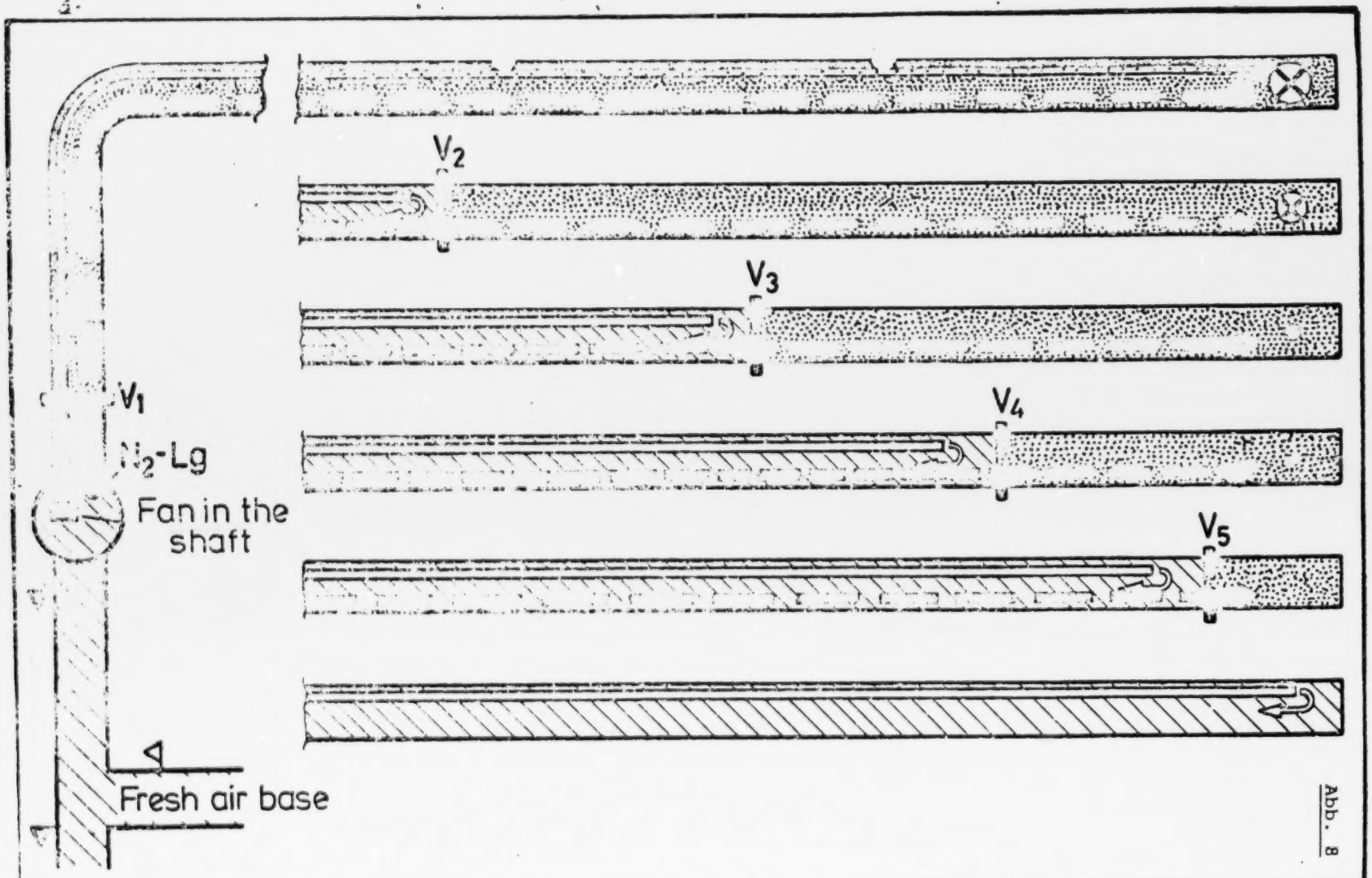


Abb. 8

1982	Stepwise recovery of the fire zone	HGRW E

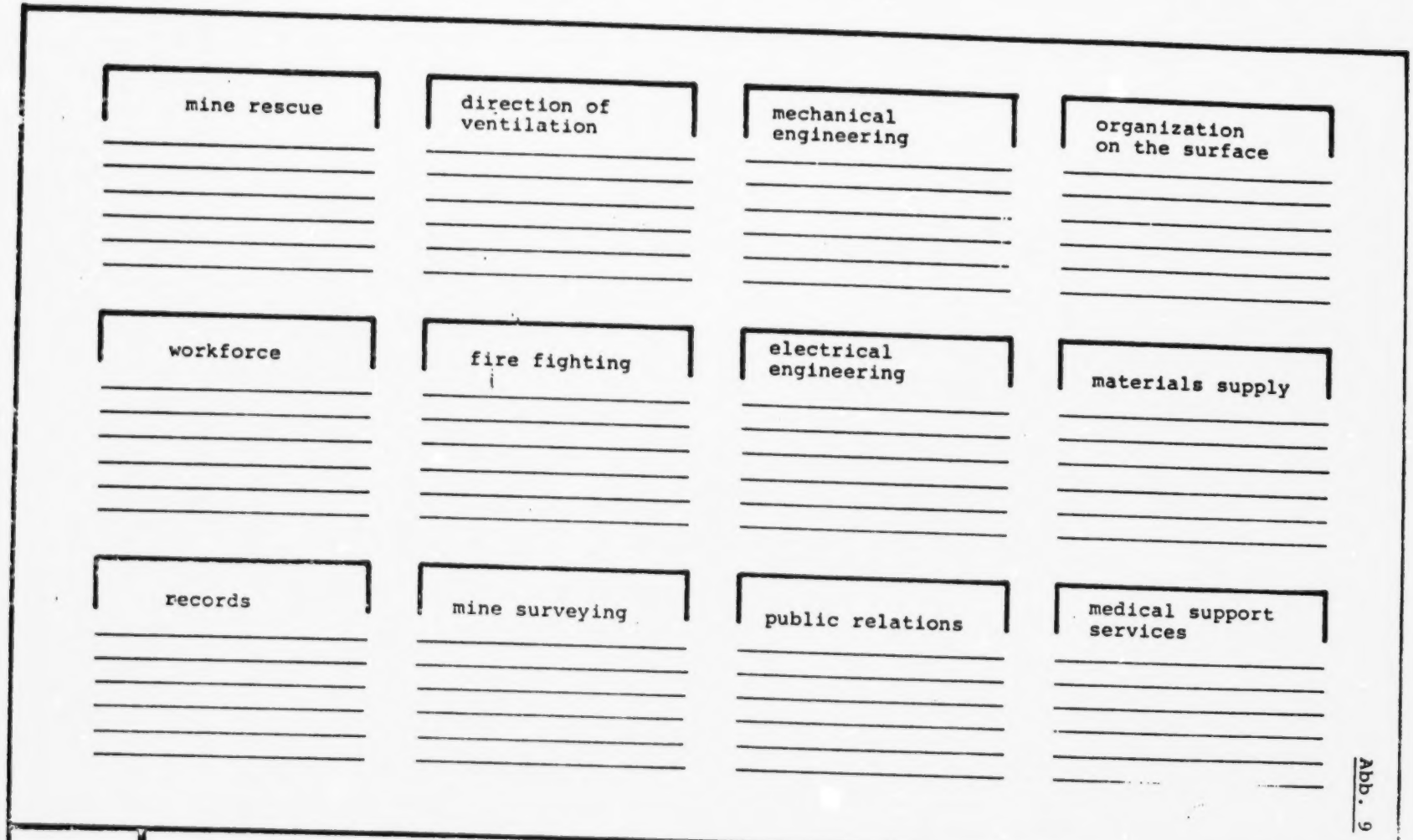


Abb. 9

1982

Duties of the management of rescue actions

HGRW E

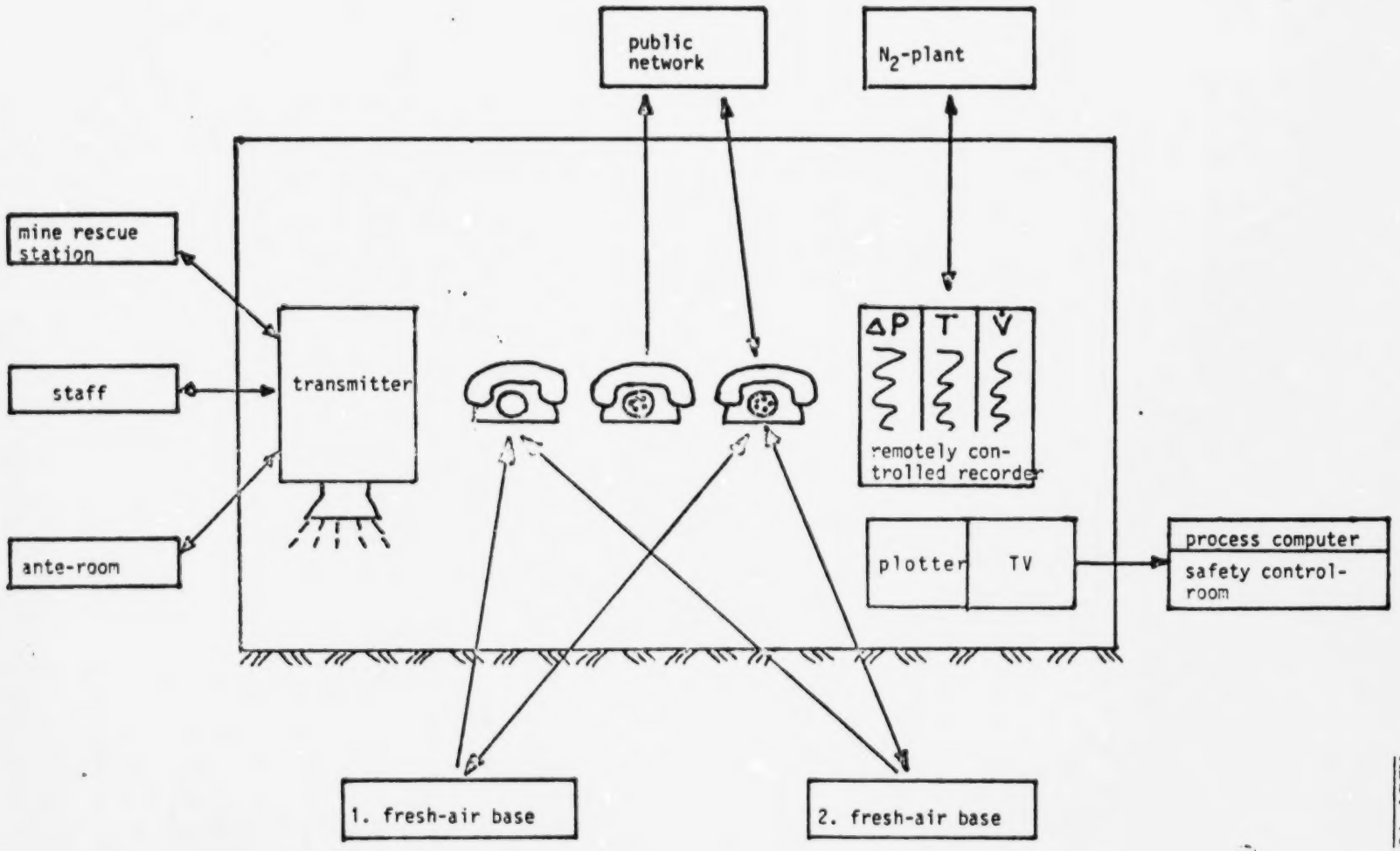
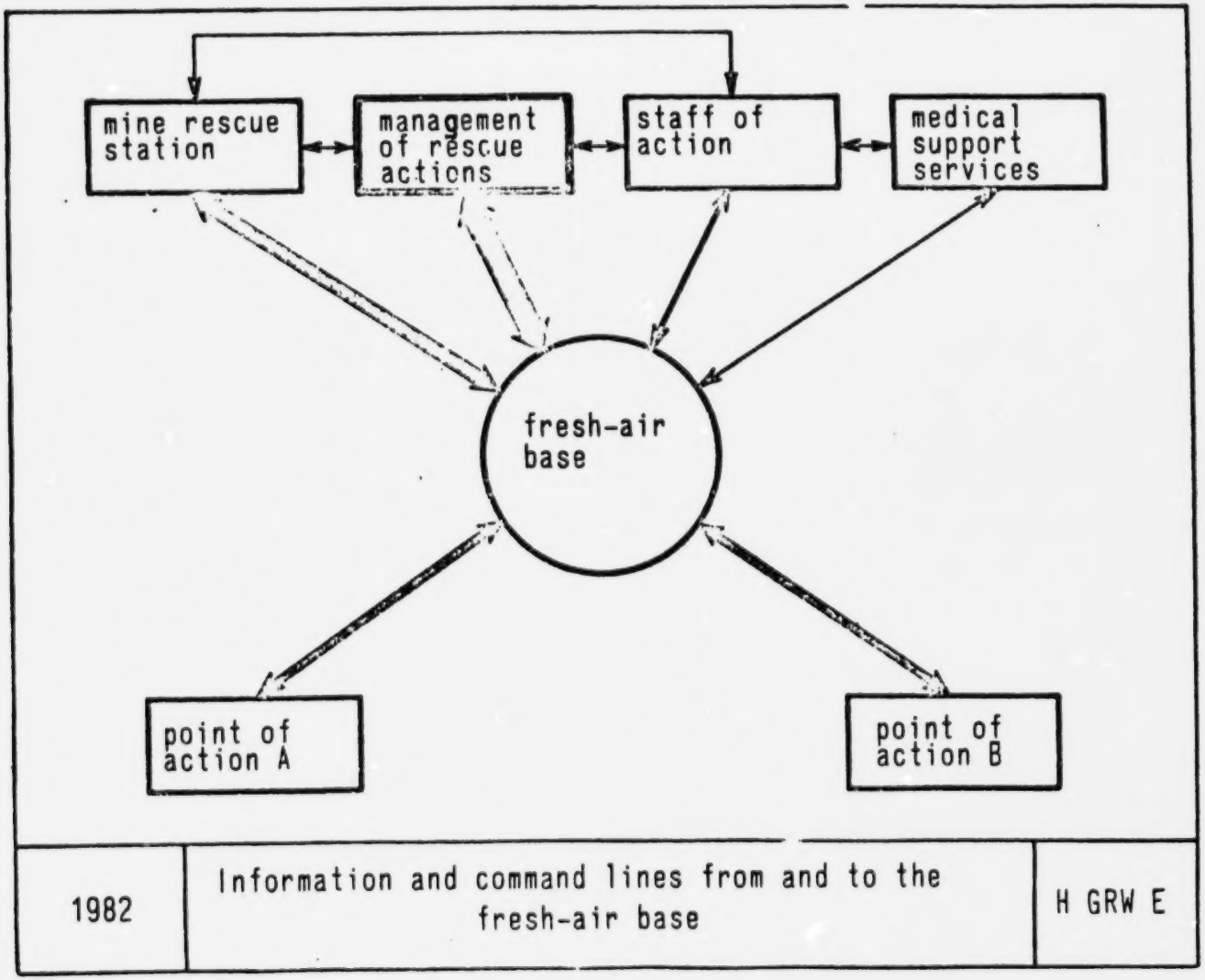


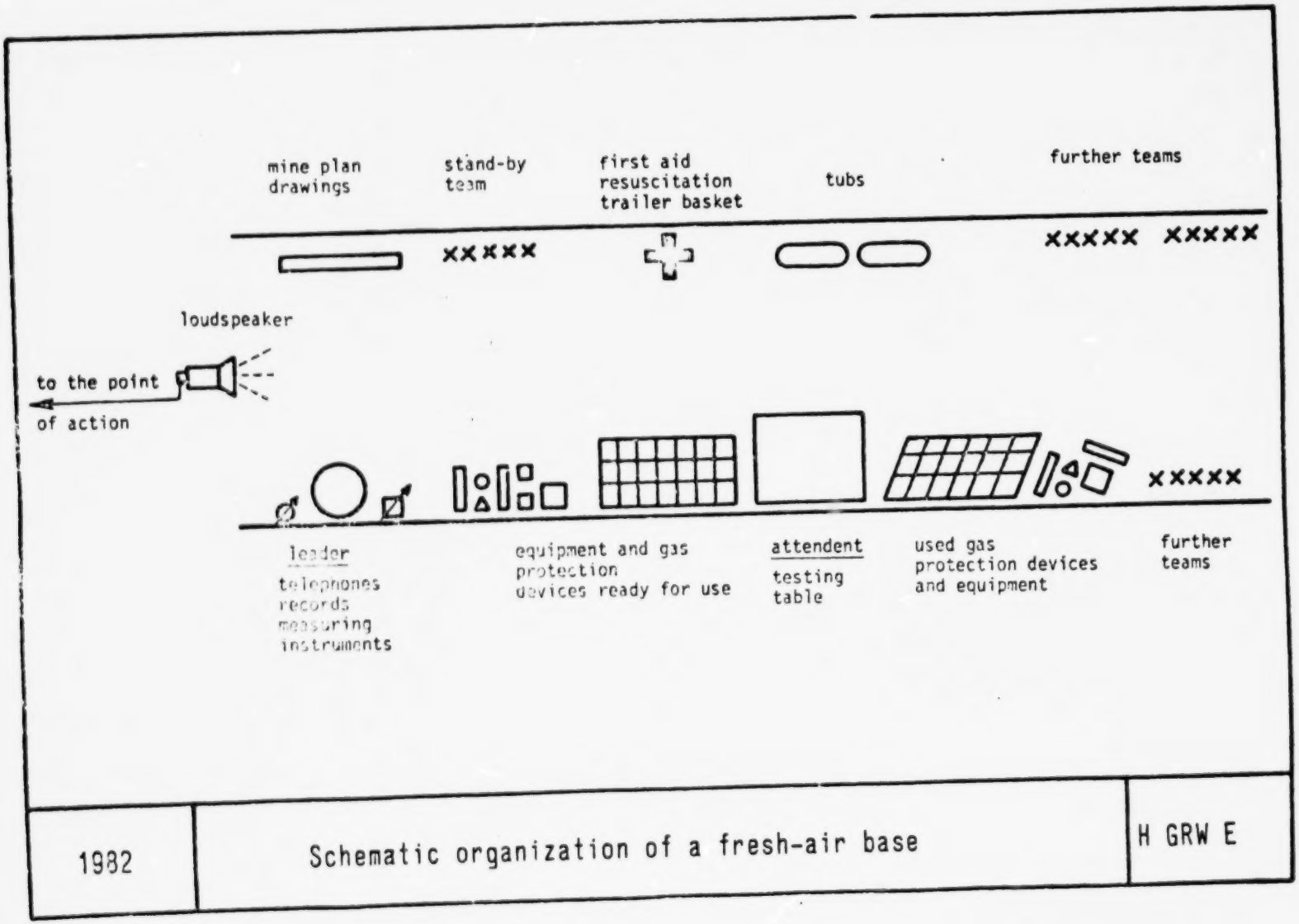
Abb. 10

1982	Communication systems of the management of rescue actions	H GRW E



1982	Information and command lines from and to the fresh-air base	H GRW E

Abb. 11



1982	Schematic organization of a fresh-air base	H GRW E

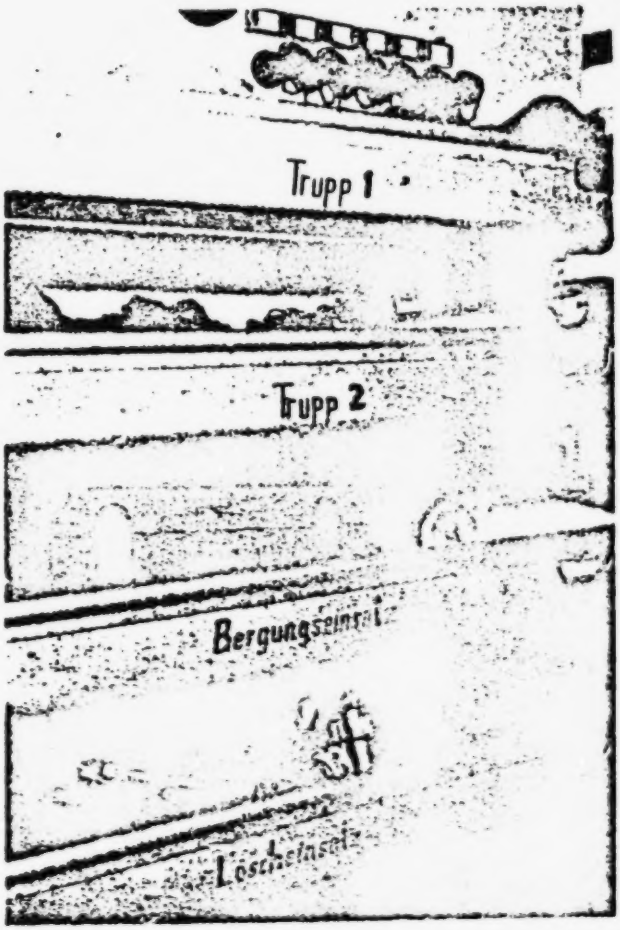
Abb. 12

wet bulb temperature t_f [°C]	duration of action in minutes for Δt^* below 5 °C	for Δt^* 5 to 10 °C	for Δt^* above 10 °C
29	90	85	80
30	80	75	70
31	70	65	60
32	60	55	50
33	50	45	40
34	45	40	35
35	40	35	30
36	35	30	25
37	30	25	20
38 - 40	25	20	15

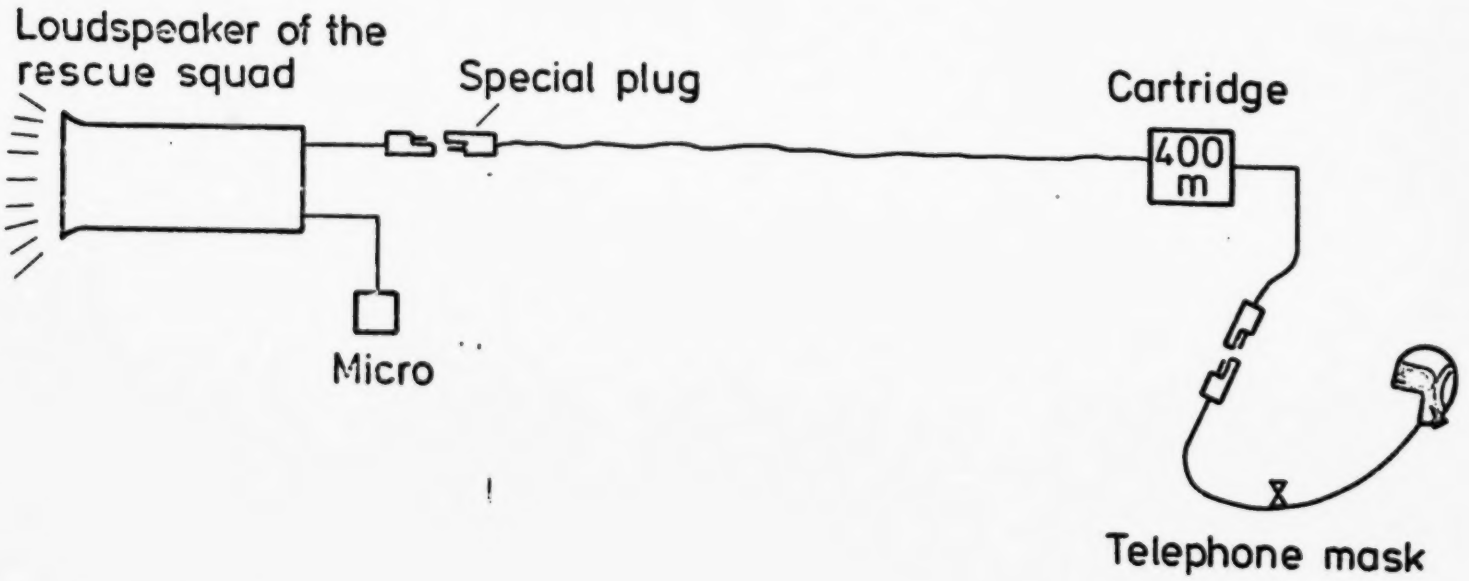
*Δt = difference between dry bulb temperature (t_t) and wet bulb temperature (t_f)

Abb. 13

1982	Duration of action by mine rescue teams in wet and warm air	H GRW E



1982	Equipment for first action by mine rescue teams	HGRW E

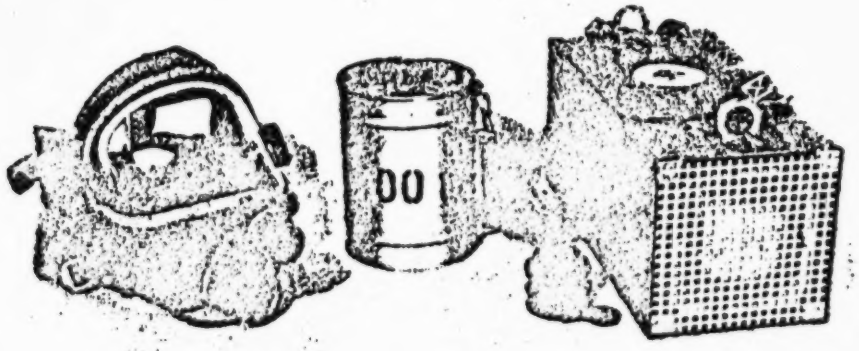


Rescue team operating under aggravating conditions during the first intervention

Abb. 15

1982	Mine Rescue Telephone I	HGRW E

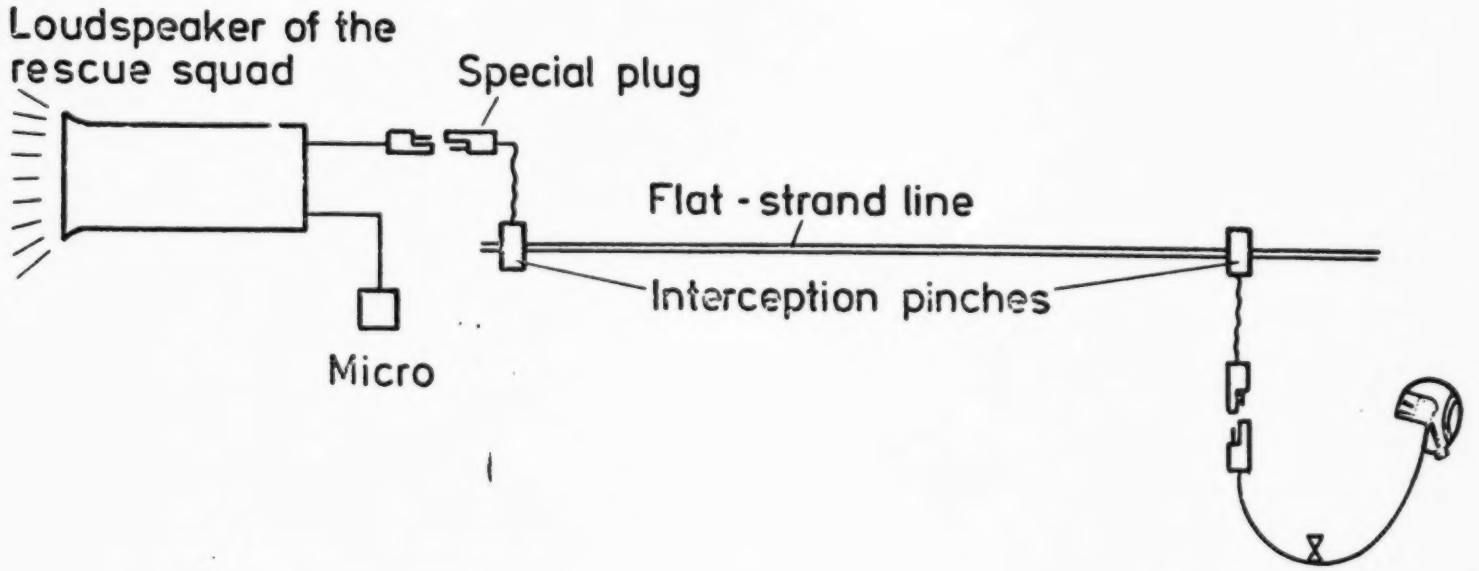
198



1982	Mine rescue telephone I	H GRWE

Abb. 16

199



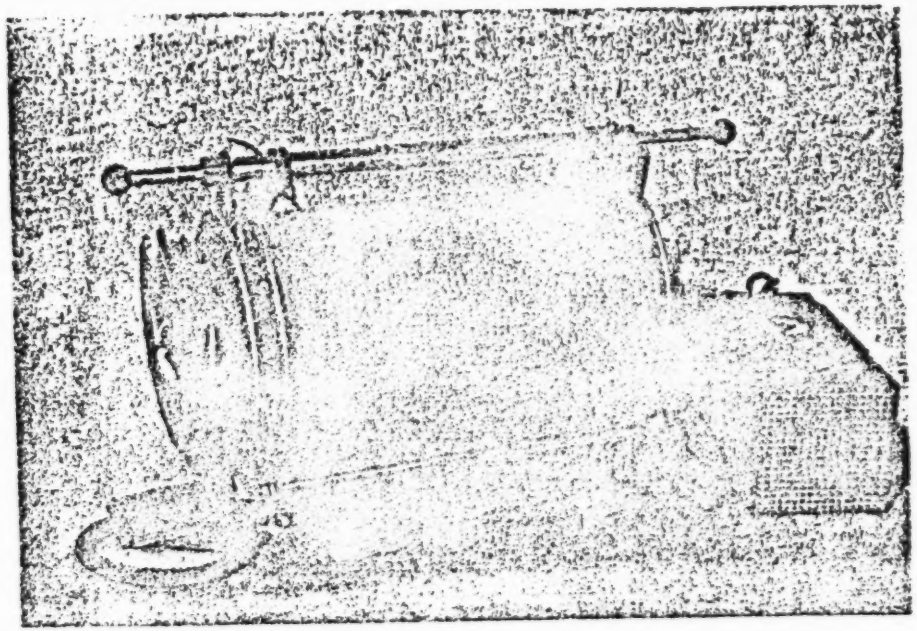
Rescue base

Place of use

Rescue team operating under aggravating conditions after the first intervention

Abb. 17

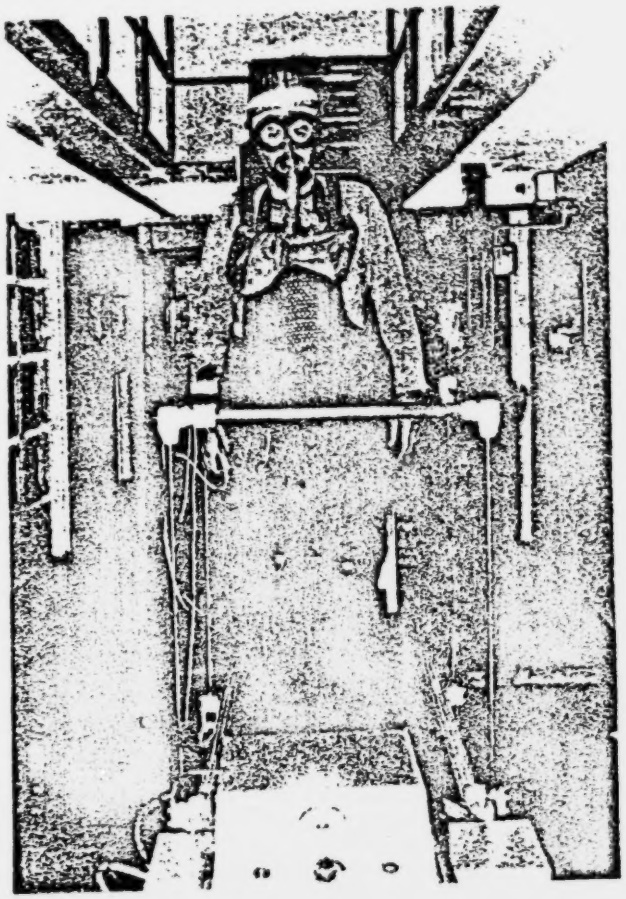
1982	Mine Rescue Telephone II	HGRW E



1982	Mine rescue telephone II	H GRWE

Abb. 18

Abb. 19



1982	Oxygen-self-rescuer type Auer SSR 120 during test	HGRWE

1982	Mine rescue team leaving fresh-air base	H GRWE

manufacturer type	application	measuring range	measuring principle
Auer M 502	manual methane measuring device	0 - 2 % / 0 - 5 % CH_4	heating tone
Auer M 510 B	manual methane measuring device	0 - 100 % CH_4	thermal conductance
Auer A 2 WT	portable explosimeter measuring device	0 - 100 % UEG	heating tone
Auer Oxygen-Indicator	manual oxygen measuring device	0 - 25 % O_2	electrochemical detector
Dräger CGMOWARN	portable CO-measuring devices	0 - 200 ppm CO 0 - 400 ppm CO	electrochemical detector
gas detector tubes	Auer / Dräger CO, CO_2 and others	different measuring ranges	chemical reaction (changing colour)

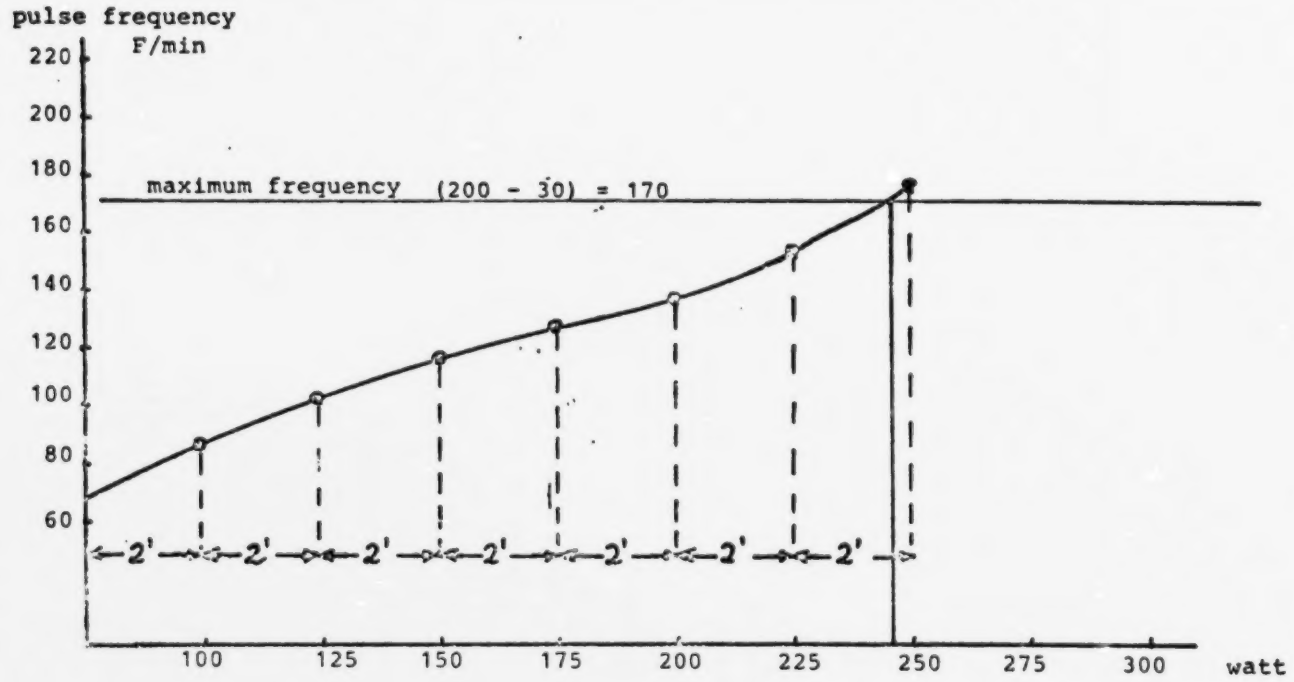
Abb. 21

1982	Manual measuring devices and portable measuring instruments	H GRW E

characteristic value	classification	percentage	
< 75	bad	14	58 %
76 - 100	moderate	44	
101 - 125	good	35	42 %
> 125	very good	7	

Abb. 22

1978	Characteristic perseverance values for 300 members of mine rescue teams	H GRW E



required: weight (kg) x 3 (watt/kg) minus 1 % per year of age above 30

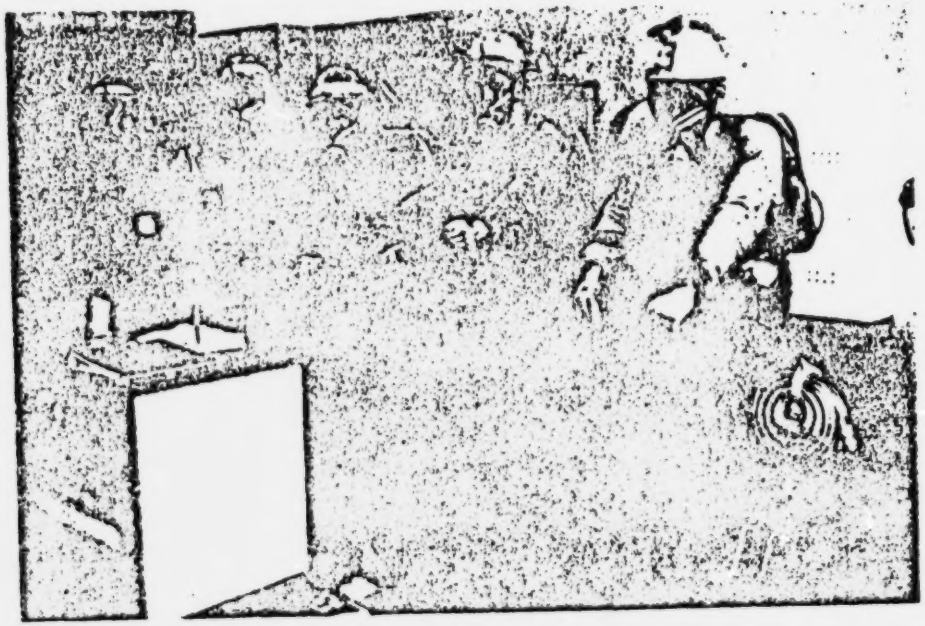
in this case: 80 (kg) x 3 (watt/kg) = 240 watt

actual: 245 watt ≙ required value + 2 %

family name: M E I E R christian name: Hans age: 30 years weight: 80 kg

Abb. 23

1 9 8 2	Occupational - medical examination of mine rescue members	H GRW E



1982	Mine rescue team on training bicycles	H GRWE

Abb. 24

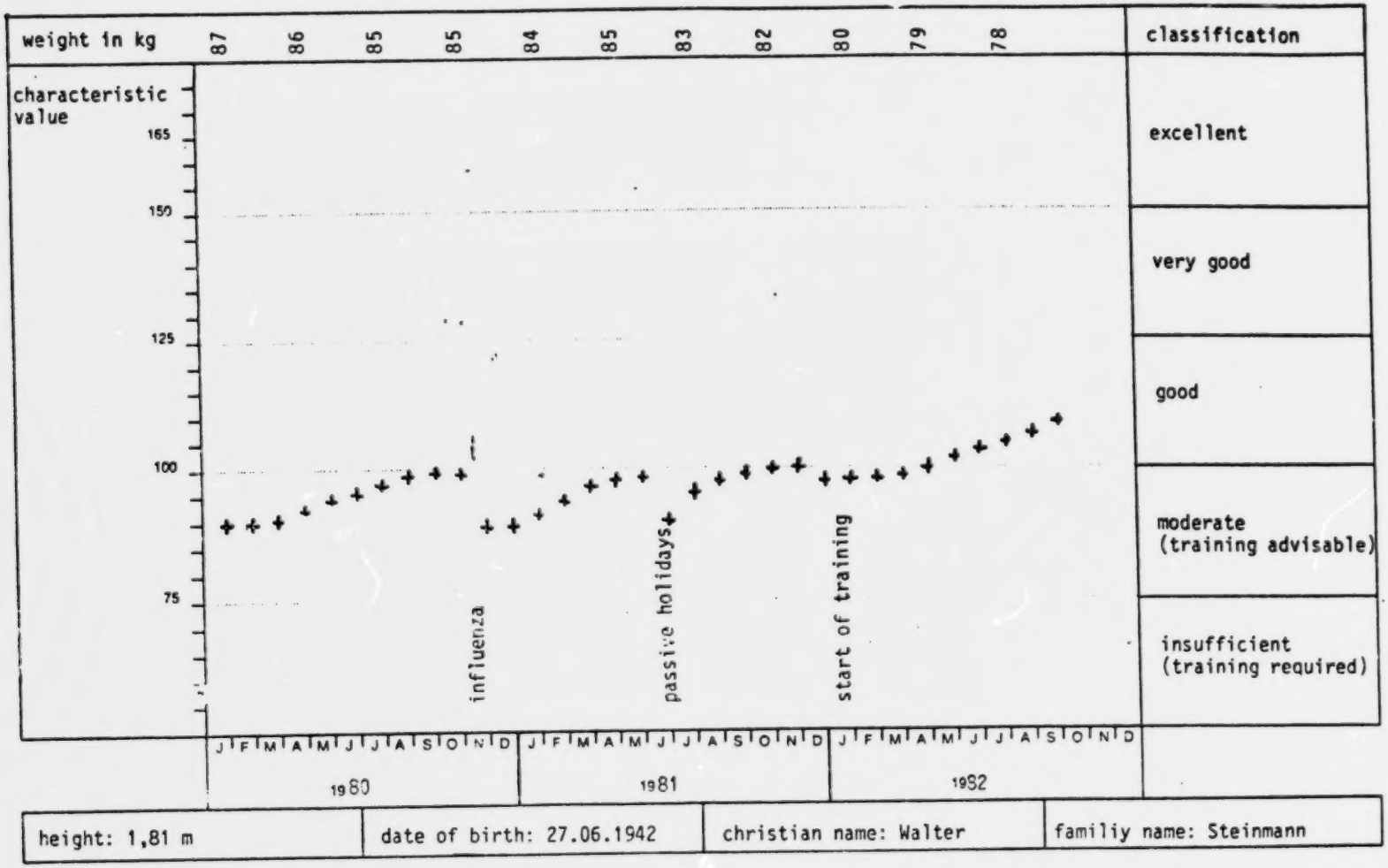
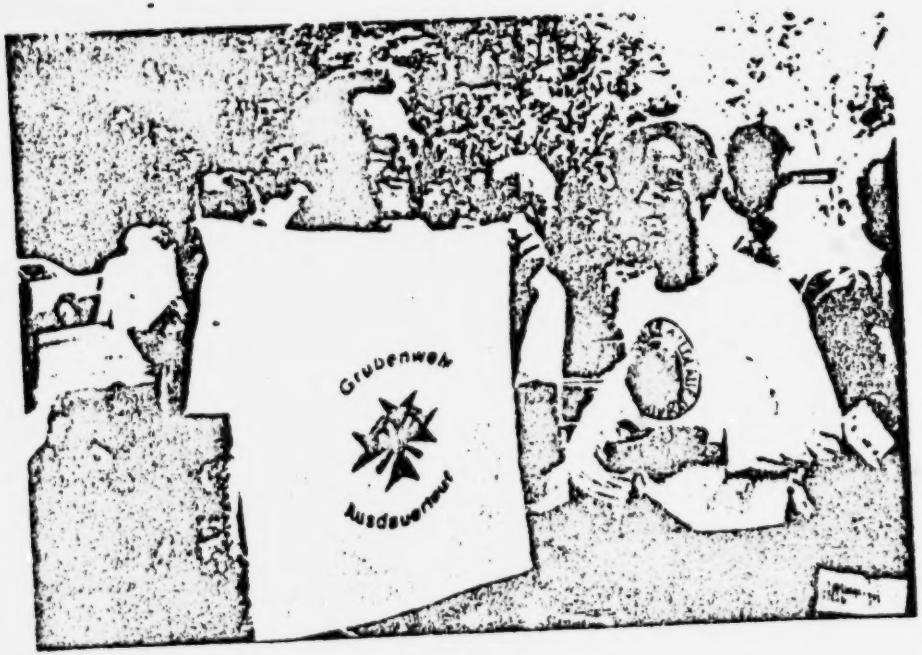


Abb. 25

1982	Perseverance chart	H GRW E



1982	Jogging for mine rescue members	H GRWE

Abb. 26

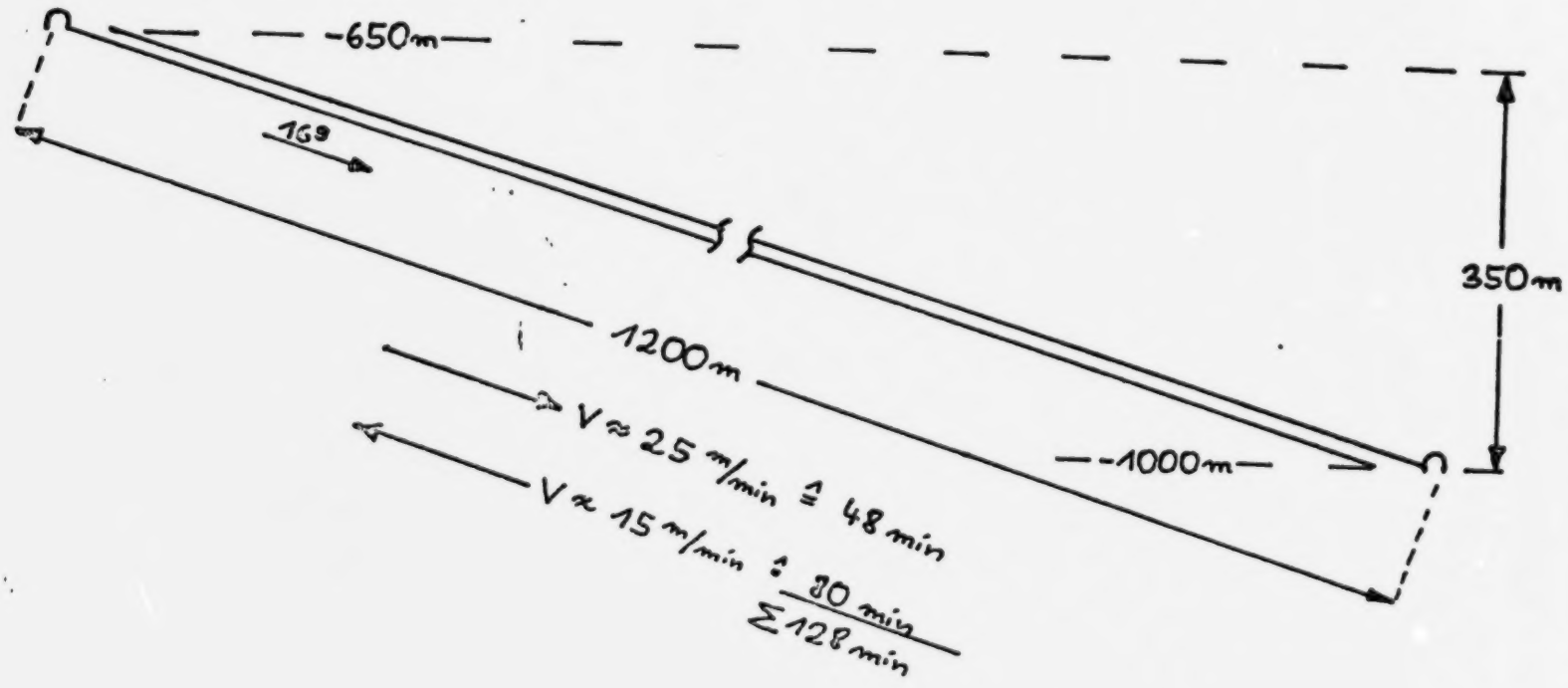
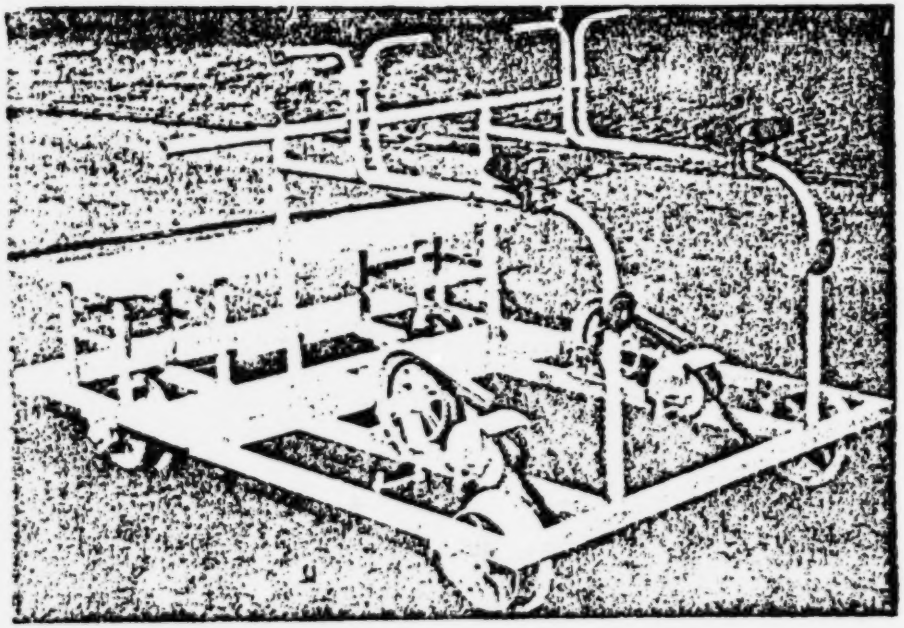


Abb. 27

1982	Travelling in drifts by mine rescue teams	H GRW E



1982	Rail bicycle for mine rescue members	H GRWE

Abb. 28
211

DISCUSSION FOLLOWING PRESENTATION OF F.J. KOCK

Q. The table showed the dry and wet temperature and the duration time depending from these figures. What is the resting time between the working and action time with such shortened action?

A. The resting time is always two hours. Many years ago, we and other European countries did a lot of research work in this field and you can find very similar figures in the European countries. We have all the same rules and the same experiences. It is a physical reason that man, although he had worked only for a short time in hot and humid conditions, has to rest two hours.

Q. Is the two hour rest under normal conditions or under warmer atmospheres?

A. I cannot answer this question. I can answer only for our conditions. If he rests in an area, let us say, up to 30 degrees celcius temperature, not higher than 30, then it is enough. But in other situations, we wouldn't have our fresh air base. Perhaps with an exception if there is some rescue work for a very short time.

Q. Do the teams always go back to the fresh air base to rest?

A. Of course, they go back to the fresh air base.

Q. In the table, you have very short action times at high temperatures. Does the action time include travelling time?

A. Yes. That means in some cases nearly all the time is non-working time. That is a problem. That is why I think all the countries involved in rescue work, especially in hot and humid atmospheres are doing research work in looking for climate suits. I think we need them more and more in the future.

Q. When do you decide to start nitrogen inertization?

A. This is a very wide field to answer. Perhaps I can give some examples. If we find a very low increasing of the CO concentration development in the goaf. Let's say in the return area you find on Monday, 8PPM, on Tuesday, 12, on Wednesday, 15, then in the second day or in the first day you start searching for the source of the CO. Normally, you would go through the stopping, along the roadside and maybe you will find high concentrations of 3,000 PPM and a Graham figure of more than 1. In such cases it depends on what is necessary to seal off the goaf. If the source of the CO is not capable of causing fires behind the face, then you have a good chance to seal it without any danger to production. But if the source of the CO is near to the face,

maybe your production is in danger, and in such a case, we shouldn't waste a moment. We say today, let's start, let's phone the enterprises, let's bring all the installations and in every pit they have done preparations for using nitrogen fast, that means the connections on the surface and the shafts are ready. They have plans in which ways you can bring down the nitrogen and so on. When you install it, it needs, as I said, between 8 and 12 hours and then you have 12 hours time to think over if you should use it or not. But if there is any doubt that your production is in a danger, you will start immediately. The other reason, of course, is if there is any danger of an explosion in the goaf, and that is in our situation very often, the CH4 concentration may be low in the return airway, that means less than 1 percent, but if you look in the goaf, you will find every concentration you can imagine, and in these cases, we introduce nitrogen as fast as we can.

Q. Unrecorded question.

A. At this conference I heard about one. Was it in the U.K.? I can tell you of some of my experiences in 1982. The problem was the heading was 2.1 kilometers long. The auxiliary ventilation pushed the air through air ducts and therefore the rescue team had no chance to reach the face. Therefore, they had to build a stopping at the beginning of the road. After 12 hours we started to bring nitrogen in the road. The problem in this case was that the rescue team were not able to bring the nitrogen hoses up to the face because the climate was so unfavorable. That means that it was really hot and you couldn't see anything. Therefore, we injected the nitrogen at first in the air ducts, but the ventilation in such a heading with a tunneling machine is one of the most complicated things I know. Therefore, we couldn't be sure that in the first moments the whole road was filled up with nitrogen. After some hours we could be sure by sampling and exploring. Then we started this operation as it was safe for us to go further and further on.

To answer the question, "how much nitrogen do you use in such a case"? What we did here was not build explosion proof seals but only some steel framing covered with brattice. That was enough. If such a seal is very tight, there is only a small amount of nitrogen necessary to fill the total road. You always put more in than you really need. At first, we used up to 150 cubic meters per minute and after some days we used only 25 cubic meters per minute and it was enough. Then they got in trouble on the night shift, as usual. What happened was they got some logistic problems on the surface without informing the crisis management. Therefore, in such cases, it is our experience, you should see in the room of the mine management all the measuring devices so you don't need special information from the men out at the plant. The second point was that they had a short interuption in their nitrogen plant and in the

following minutes, they tried to bring a little bit more nitrogen hose underground. A hose broke, the nitrogen didn't reach the face and it was some time before anyone noticed it. Then we had a small explosion. It happened a second time in a very similar way. Of course, all mine authorities say there was a mine explosion. In my opinion there was no explosion, it was the burning of a little bit of methane, without any pressure.

Q. Did the nitrogen line freeze up?

A. No. But we did have such experiences from some years back. This point is an important point, especially in the first meters if you make the connection between the evaporator on the surface and the pipe in the shaft. We do it normally with 150 diameter hoses. What we want is to have nitrogen as cool as possible. It is good for the rescue team. But there is a freezing danger especially immediately after the evaporator. If you look for a limitation in the temperature, the minimum should be 10 degrees C, then there should be no danger. Modern vaporators do this automatically. They have a lower temperature limitation and an upper temperature limitation. There is another danger if the temperature rises, the hoses may blow.

Q. Is it mandatory to have facilities for transporting nitrogen in the mines?

A. No. Our mine authorities have found, in my opinion, a very wise solution. They say if any operator wants to use nitrogen in the case of fire, he has to make a plan. Of course, it is impossible to do all those things if there is a fire. That means that you must prepare a plan and therefore they all did the plans and have made preparations. Only in a few cases do you need separate pipes. Normally you can use any pipe that you can make free without danger to your production. There is only one problem that you have to solve very precisely. That is what part can you use in your shaft. There are some very modern collieries that say that this question is so important, that they have installed a separate pipe only for inertization.

Q. Is there a corrosion effect on steel pipes?

A. I can not imagine. It is an inert atmosphere. We have never had such a problem. The problem when we started was another question. In 1974 for the first time we used a mine water discharge pipe and thought it must be big enough in diameter. We had some explosions and inertization was the only way of saving the whole colliery. There was no other chance. It worked very well when it was started but we couldn't bring the amount of nitrogen down through this pipe that theoretically should have come. The explanation was that it was encrusted. We never pump liquid nitrogen. It was evaporated on the surface.

EMERGENCY RESPONSE MANAGEMENT IN A REMOTE LOCATION - A CASE STUDY AT McINTYRES SMOKY RIVER COAL OPERATIONS

PRESENTED BY

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McIntyre Mines Limited
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Most of the papers given earlier in this Symposium refer to coal fields with situations different from that in Western Canada. The location of the incident described in this paper was at an underground coal mine some 150 kilometers from any other mining operation and some 500 kilometers from the nearest underground coal mine. This situation contrasts with that of people operating, for example, in the Rhur coal field, or Lorraine, or in the Midland coal field of the U.K. In all of these places, there are tight groupings of mines and resources can be pooled and used to cover a number of mines. In the case of Western Canada, as the incident clearly underlines, we need to be self-sufficient.

The objectives of the paper are first, to describe an underground fire at mine 2R-4, one of our underground mines; second to review the events and actions taken, and third, to suggest what might be learned from the incident.

The McIntyre coal operations are located at Grande Cache, Alberta (Fig. 1). This is in the northwest part of the province in the foothills of the Rocky Mountains, almost on the border of British Columbia. The nearest major cities are Edmonton and Calgary, both with populations of around half a million people. Grande Cache is approached either by air or by road. The distance from Calgary to the mine by road is some 620 km, by air some 430 km (Fig. 2). Edmonton is some 430 km by road and 350 km by air. Grande Cache has its own Provincial airport and there are also Provincial airports at Hinton, Edson and Grande Prairie and major airports at Edmonton and Calgary.

The Town of Grande Cache has a population of approximately 5,000 people. It is a complete community which was developed to house people working at McIntyre's operations which started up in 1969. The town itself was built in the early 1970's, and facilities include a 30 bed hospital, schools and a recreation center. Medical services are capable of handling almost all situations. The main minesite is on the Smoky River, about 15 km from Grande Cache.

At the time of the incident, in October, 1980, there were five underground mines in production plus one being developed, and a major surface mine (Fig. 3). The road distance from the main plant to mine 2R-4 where the incident occurred was some 15 kilometers.

The mines feed a preparation plant, which turns out a 7 percent ash, less than half percent sulphur, 18.5% volatile and 7 FSI high quality metallurgical coal, all going into the export market. The mining system in use in all of the underground mines was room and pillar, with continuous miners. We had 350 underground employees. Our average daily production from all of the underground mines was some 4,300 tons, with an annual production of just over one million tons.

The mine in which the incident occurred, 2R-4, was an adit mine, working from the outcrop in some fairly steep terrain. A bench had been created on which three portals had been established (Fig. 4). Like most of the underground units, the mine was planned for a relatively short life, since the geology, which is fairly complex, breaks the area up into a series of discrete coal blocks. At 2R-4 mine the No. 1 entry was the belt entry, with a conveyor system bringing coal from underground onto a stacker belt, which stockpiled the coal for loading by front end loader into trucks. No. 2 entry was the materials access with an open portal providing access for rubber tired free steered materials vehicles. No. 3 entry was the return entry equipped with a set of four 54" exhaust fans. A pond provided water storage near the portals. The seam height was 22 feet with a working height of some 12 feet.

Production was from continuous miners, loading into shuttle cars, which discharged onto the conveyor system. Roof support was by 6 foot roof bolts on a 4 ft. by 4 ft. pattern, with steel mesh above.

At the time of the incident, the management organization (Fig. 5) consisted of a General Manager, in charge of all the Smoky River operations. He was supported by an Assistant General Manager, whose responsibilities were for production - surface, underground and coal preparation. The Manager (Underground Mines) had two Assistant Mine Managers, each of whom was responsible for three of the underground mines. The Manager (Safety) reported directly to the General Manager and was responsible for all safety aspects at the property.

The three rescue teams were the direct responsibility of the Manager (Underground Mines) (Fig. 6). The training of the teams was the responsibility of the Manager (Safety) through a Rescue Officer. There was a functional link between the Manager (Safety) and the Manager (Underground Mines) and between the Rescue Officer and the rescue teams through the Assistant Mine Managers. The main emergency facilities (Fig. 7) were located at the main plant site, where there was a treatment room, two rehabilitation areas, a fire truck, two ambulances, a water truck and 18 sets of apparatus. At 2R-4 mine there was an ambulance and a first aid room.

On Sunday morning, October 26th, an electrician carrying out routine inspections on the surface observed smoke coming of the No. 3 return entry of 2R-4 mine (Fig. 8). There was nobody working in 2R-4 at this time. The mine workings extended some 1½ kilometers along the strike and approximately 700 meters across the dip (Fig. 9). At the time, most of the mine had been depillared and caved.

The area of coal still unmined contained about 150,000 recoverable tons - about three month's production - and was known as 1 South (Fig. 10). Coal was conveyed to the surface from this district by two belt conveyors. Mining was being undertaken in one section only, because of the relatively small area left to work.

The firefighting system (Fig. 11) consisted of a 4 inch water main in the conveyor roads, an underground sump and a reservoir on the surface.

The smoke was observed at 9:50 a.m. and the alarm was raised by a phone call to the mine control room. Calls went out to alert management and the rescue teams. It was a Sunday morning and people had to be contacted in town, and brought out to the mine. At 12:30 p.m. the first team arrived on site at 2R-4 mine. Between approximately 10:00 a.m. and 12:30 p.m. they assembled, travelled some 30 kilometers, prepared their apparatus, checked it, travelled from the main plant site up to the mine and reported for work. By 1:30 p.m. the second team had arrived and the first team was then able to make an underground inspection to determine the extent of the fire. After this inspection attempts were made to fight the fire using the water system. By 2:15 p.m. the efforts were suspended because it was proving impossible to make any headway. The fire had already taken a strong hold and a wooden side props were on fire in places. The belt conveyor was also alight. At 2:20 p.m., after the fire fighting efforts were suspended, it was decided to control the incident by building seals at the portals. It was also clear that this sealing operation could not be sustained by the rescue people available on site.

At the time of the incident, weather conditions were deteriorating and both the airport at Grande Cache and the highway from Edmonton to the mine were closed, severely hampering access for outside assistance. Help was requested from Idaho and Nova Scotia. Idaho was one of the closest locations, at a distance of 1100 kilometers and Nova Scotia was 4,600 kilometers away (Fig. 12). Although 2R-4 mine is in a populated area of western Alberta, it is a long way from outside specialist help!

At 2:20 p.m. the stopping construction commenced. The plan was first to build stone dust bag stoppings, fitted with steel tubes with explosion-proof doors at the No. 1 and 2 portals (Fig. 13) and then to build a similar stopping at the No. 3 return entry. At 4:30 p.m. we set up regular monitoring of the return air. At 8:00 p.m. we had to stop construction. The stoppings were originally being built by men without apparatus because they were close to the surface and satisfactory ventilation conditions prevailed. Between 2:20 p.m. to 8:00 p.m. conditions deteriorated and the smoke buildup became quite severe at the stopping sites. It was considered unwise to continue the sealing without rescue cover, and at 8:00 p.m. the operations were suspended.

The decision was then made to attempt to control the fire using foam. The equipment had to come from Edmonton, and was scheduled to arrive the following morning, Monday morning, October 27. Foam generation was started at 9:00 a.m. in the No. 2 materials entry, with the objective of flooding the fire area with foam. However, the technique proved ineffective in our conditions.

The stopping construction continued during this time. At 5:50 p.m. when the stoppings were partly completed in the No. 1 and 2 entries, 20 minutes after the Idaho team arrived on site, the fire broke through to the fans which had been running at a reduced throughput. Methane had been identified regularly in the mine and with the large gob area the potential interaction between methane and the fire was difficult to predict. The decision was made to suspend sealing operations and allow the fire to burn out.

At 6:45 p.m. the Nova Scotia team arrived. It may seem a long time - 27 hours to get from Idaho and 29 hours from Nova Scotia - but weather conditions were very unfavorable and access to the airport restricted. The responses were as good as we could have hoped for and we were grateful for the help.

The incident comprised two main phases. The first phase was the attempt to save the mine. Nobody was in the mine when the fire was discovered and it was not our intention to put anyone at risk when taking counter-measures. the location and size of the fire was evaluated by the first rescue teams and efforts were made to fight the fire with water. When this was unsuccessful it was decided to seal with stoppings and concurrently to attempt control with foam. When none of these approaches worked, we abandoned active counter measures. We were then in the second phase - the permanent sealing of the mine. At the time the decision was made to abandon phase one, flames were visible on the surface, the coal ribs could be seen burning in the entries and flames were coming out through the fans. It was possible that the fire could spread along the exposed outcrop and cause serious environmental problems.

We decided to drill large diameter boreholes from the surface to intercept each of the three main entries (Fig. 14) and to plug the entries with concrete placed through the drill holes. This was unlikely to be totally effective because measurements indicated that the temperatures down the holes were in the plus 800 degree range and so some difficulty in making a complete seal was anticipated. Consequently, it was anticipated that after the concrete plugs had been placed, we would stow up the mouth of the entries with a fly ash/gravel mix (Fig. 15).

A road was bulldozed above the portals to access drilling sites over the three entries and a drill rig was brought in from the surface mine to drill 9½ inch diameter vertical holes about 150 feet deep to intercept the entries. Concrete was placed down these holes using a fleet of ready mix trucks from a local contractor and a concrete placing pump rented from a high rise construction site in Edmonton.

Before stowing was commenced, though it was difficult to see clearly, it appeared that there had been a reasonable build up of concrete. This formed a barrier against any explosion that might have taken place inbye. A barricade of loose rock was bulldozed up to the portals, on top of which stowing pipes were laid connected to a stowing unit

obtained from Cominco's Sullivan Mine. Crushed rock, gravel and flyash mix were loaded into this stowing combine and blown in using the compressed air to put on a plug at each portal (Fig. 16). It could be clearly seen that the stowing was tight up to the roof.

This second phase was completed by bulldozing rock and fly ash until the whole of the outside of the portals and the outcrop of the seam were covered.

The cause of the fire is still unknown. From the statements made the probability is that it was a belt fire somewhere around the main transfer point. It was impossible to gain access to the mine again after the incident, so at present the cause is still unconfirmed, but current mining plans contemplate an open pit mine at 2R-4 (Fig. 17), so that in the future the area may be exposed and evidence collected that may indicate what really happened.

What are the lessons to be learned? First, and most important, the mine inspection system failed to detect the fire in the early stages. There were no inspections planned in the mine between Saturday lunchtime and late Sunday afternoon. Second, outside help may well be delayed. Third, three local teams cannot sustain rescue operations beyond four hours by virtue of the necessity for cover and rest periods. Fourth, the foam generation technique as applied was not effective. Fifth, the manual placing of stoppings in large cross section entries was slow and labour intensive, even though the construction was initially undertaken by men without apparatus and relatively close to a ready supply of materials. Finally, the absence of local laboratory facilities made the assessment of the progress of the fire difficult.

Since the incident, inspection and fire prevention procedures have been upgraded. These are now carried out on a basis similar to that practiced in other coal fields. They include systematic inspection of belt conveyor systems after they have been stopped.

Rescue team strength has been increased to provide six teams that can work on a rota for at least 48 hours, which provides time for outside help to arrive in anything but the most exceptional conditions. In addition, the bench technician concept has been adopted to facilitate use of the same apparatus by several teams in succession and enables response time to be significantly improved.

A system has been procured from Europe for the mechanical placing of stoppings with equipment located on the mine surface, pumping sealing material to the part of the mine in which it might be required.

Concurrently with the company's activities, the Alberta government is working on the possibility of setting up a mobile laboratory facility. This could perhaps be made available for the whole of western Canada, covering Alberta, British Columbia and Saskatchewan.

Efforts have been made to upgrade rescue team skills through training practices and participation in competitive activities. Senior management capabilities have been enhanced and experienced staff are in post at the Mine Manager and Assistant Mine Manager level. Professional engineering expertise is also available in house to give technical backup during an incident.

We have responded to the lessons of the incident. We have put ourselves in a stronger position to handle similar incidents should they arise. We recognize that as long as we are the only underground coal mine within hundreds of kilometers of any similar activity, we must be ready for an initial response to any incident and self sufficient for at least as long as it may take back up to arrive in adverse conditions.

McINTYRE MINES

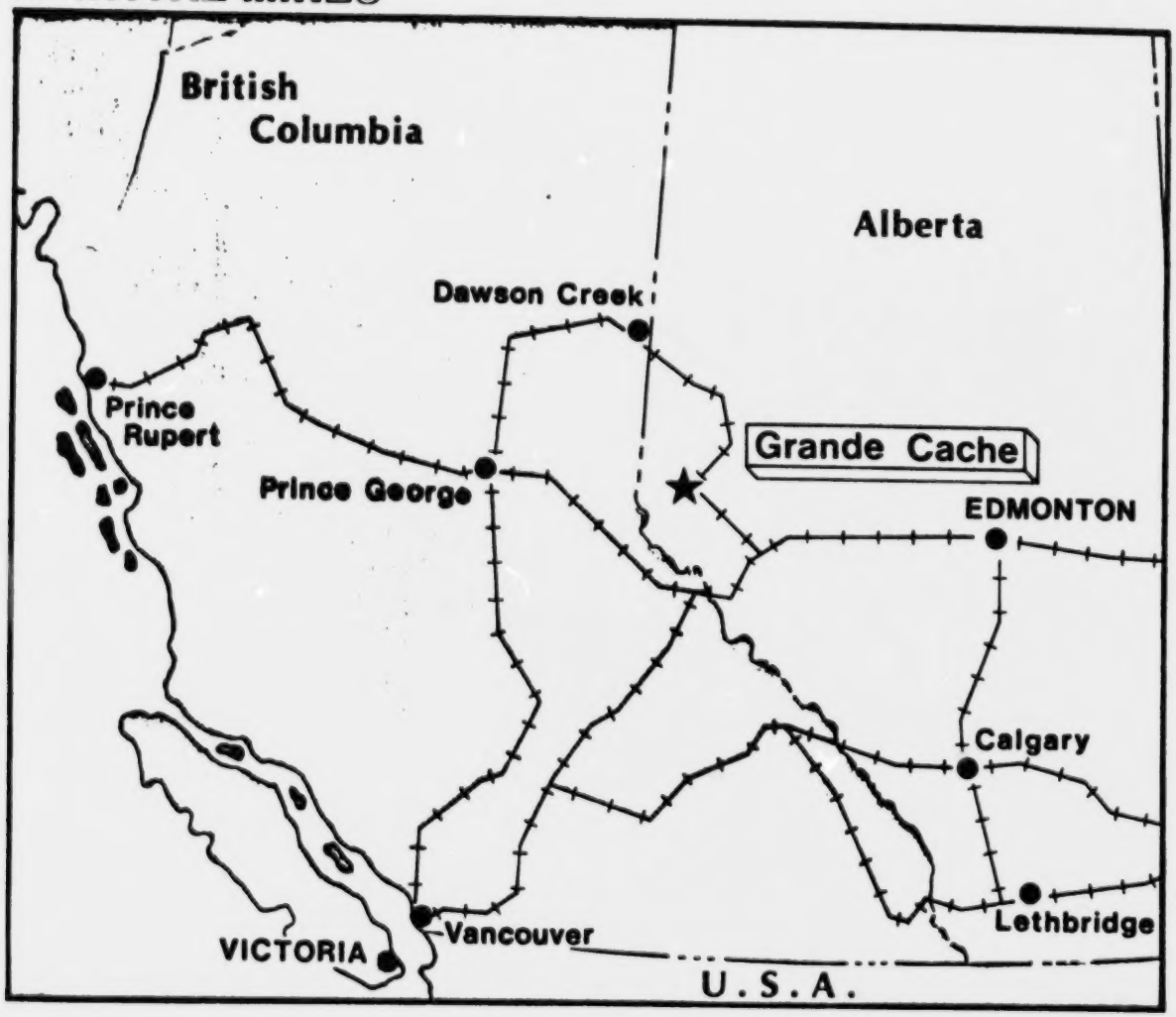
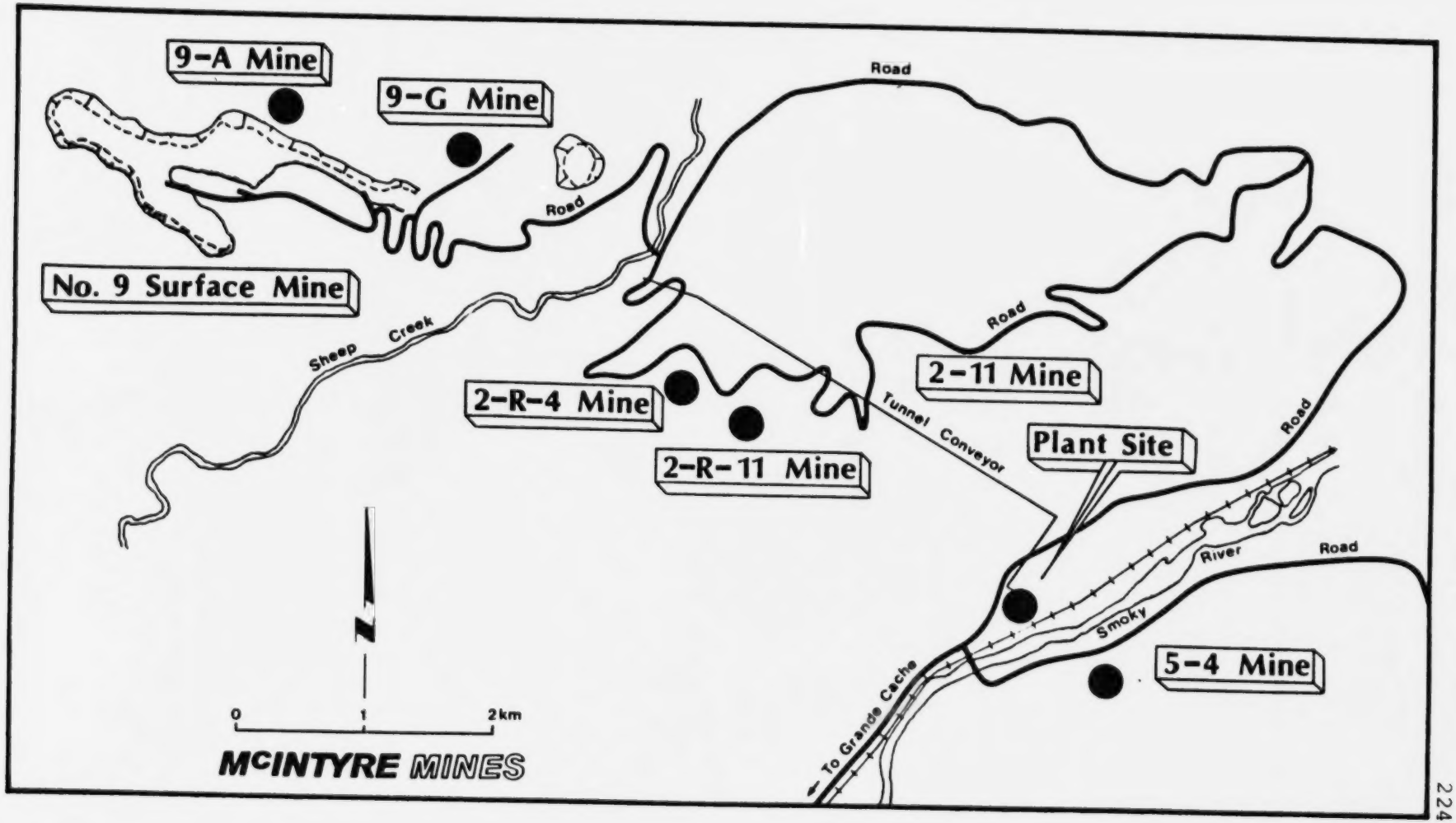


FIG. 1

ALBERTA
Grande Cache
EDMONTON - G.C.
350 km
EDMONTON
EDSON
HINTON
EDMONTON - G.C.
433 km
CALGARY - G.C.
430 km
BRITISH
COLUMBIA
CALGARY - G.C.
617 km
CALGARY
McINTYRE MINES

FIG.2


9-A Mine
9-G Mine
Road
Road
No. 9 Surface Mine
Sheep Creek
2-R-4 Mine
2-R-11 Mine
Tunnel Conveyor
Road
2-11 Mine
Plant Site
Road
River
Road
Smoky
5-4 Mine
To Grande Cache
0
1
2km
McINTYRE MINES

224

FIG.3

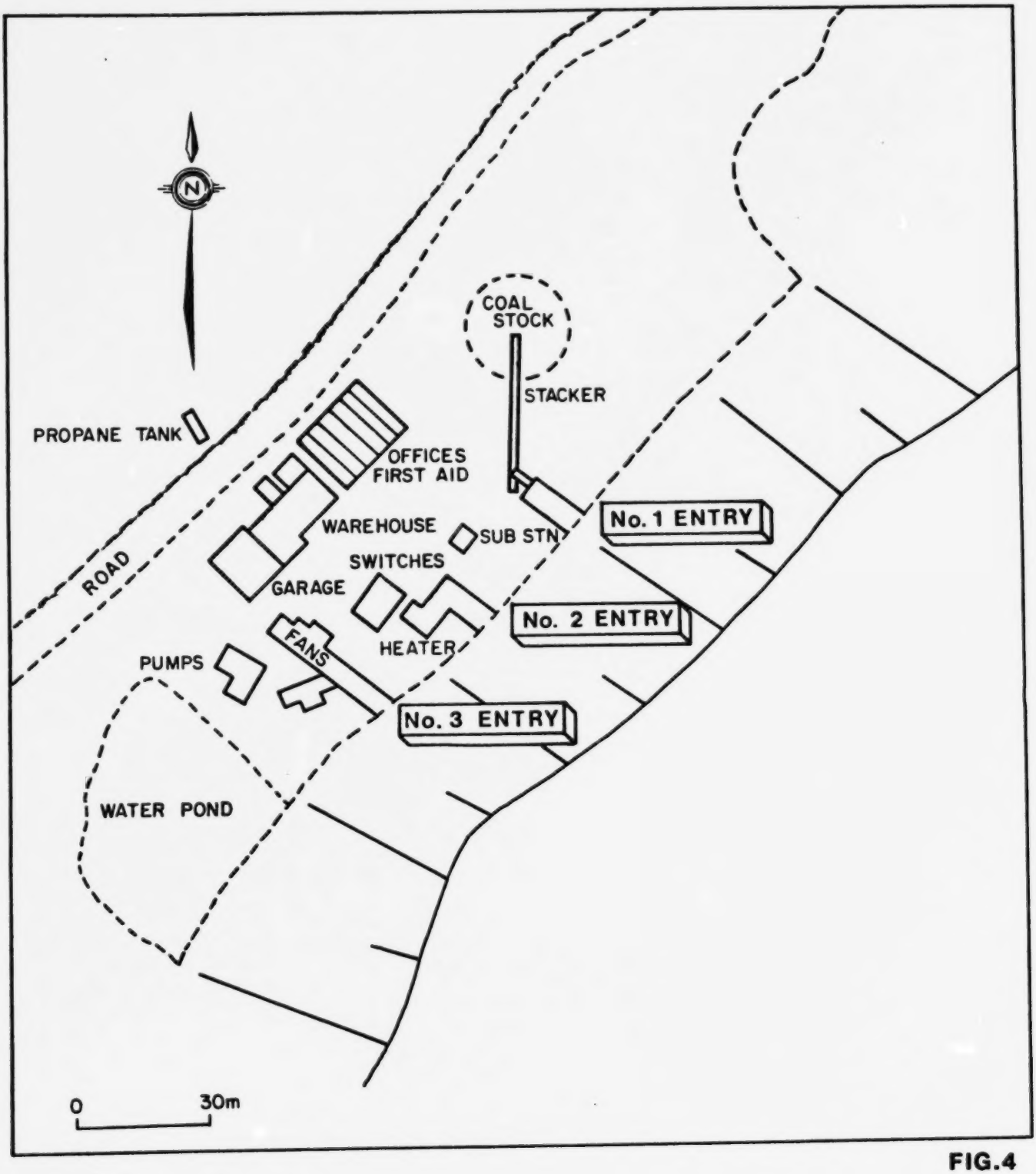

N
COAL STOCK
STACKER
PROPANE TANK
OFFICES FIRST AID
WAREHOUSE
SUB STN
No. 1 ENTRY
ROAD
SWITCHES
GARAGE
No. 2 ENTRY
FANS
HEATER
PUMPS
No. 3 ENTRY
WATER POND
0
30m

FIG.4

LINE ORGANIZATION

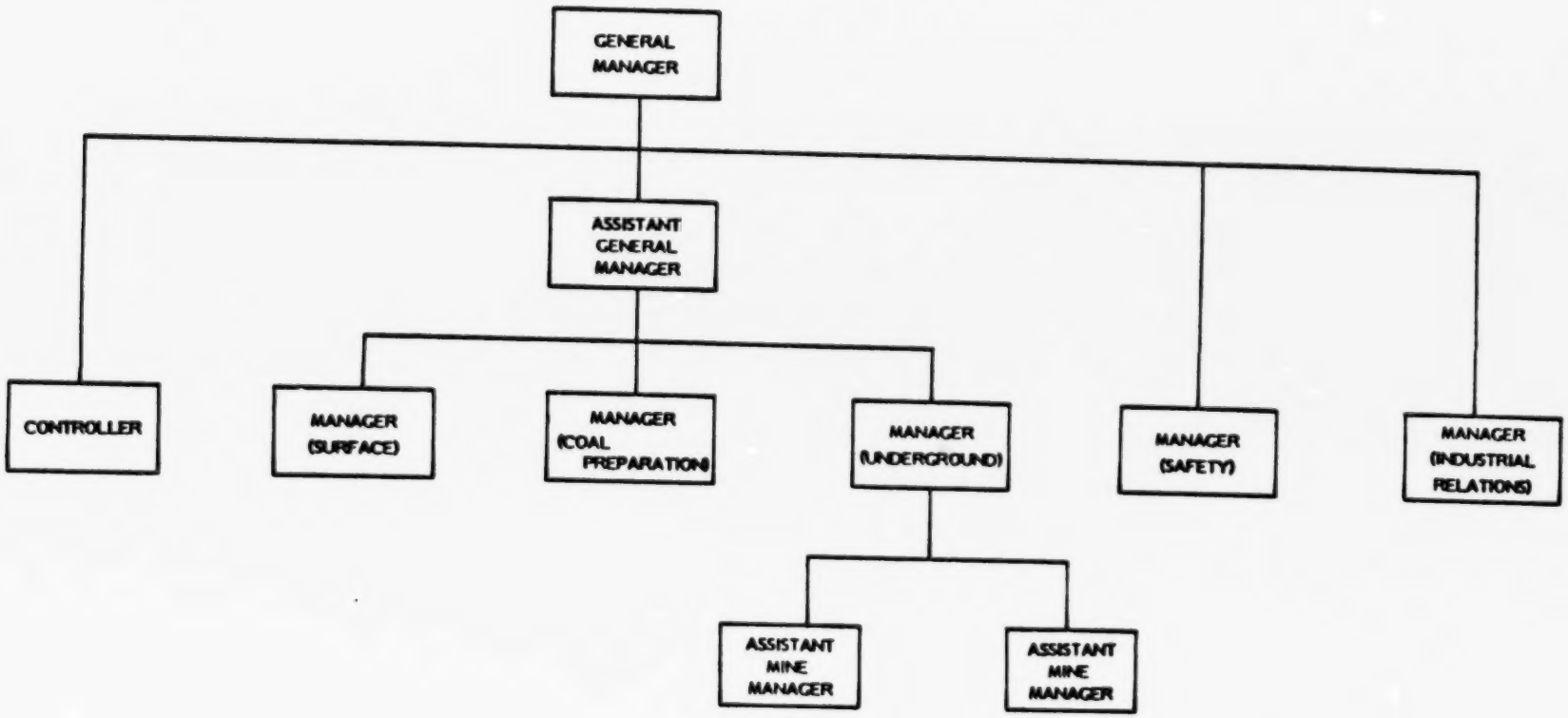


FIG.5

RESCUE ORGANIZATION

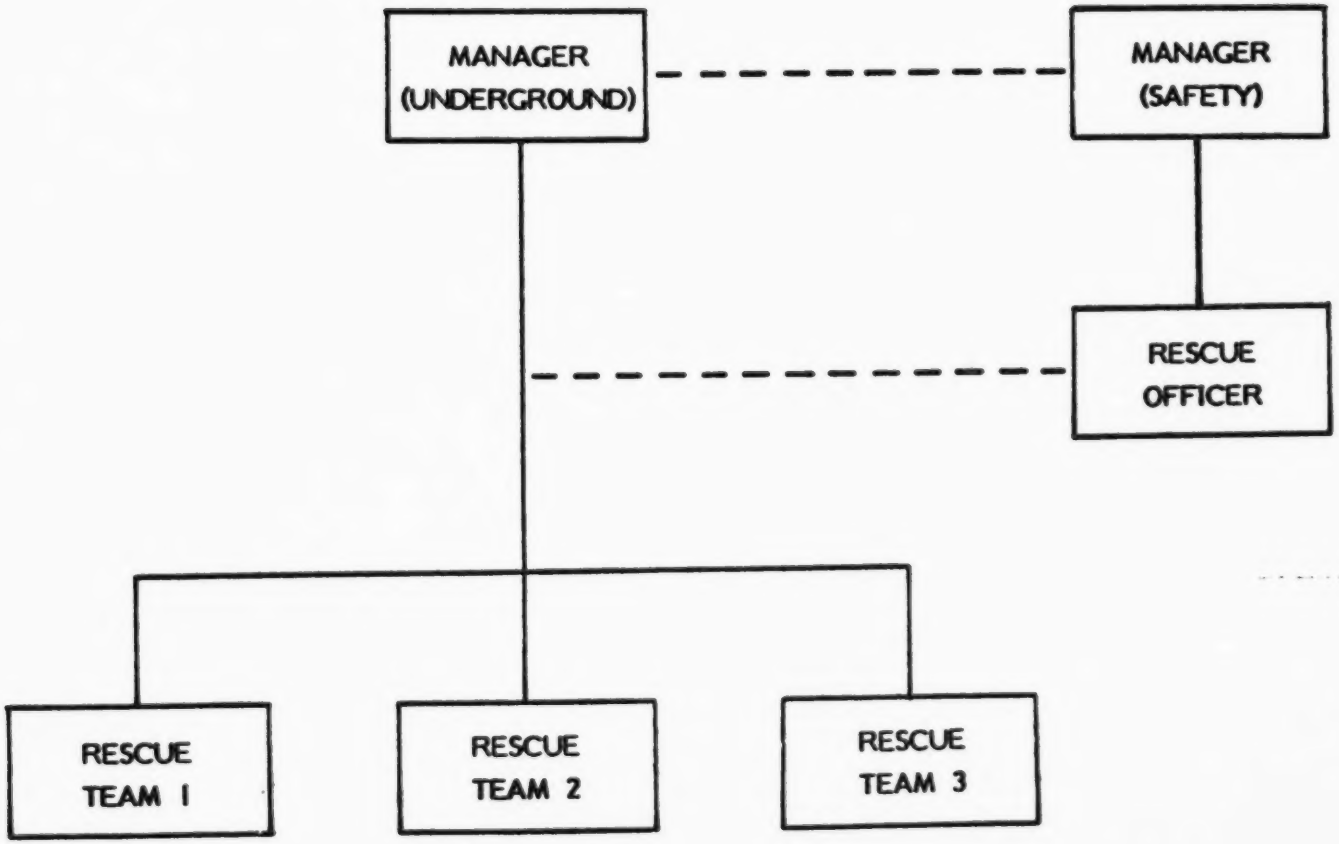


FIG.6

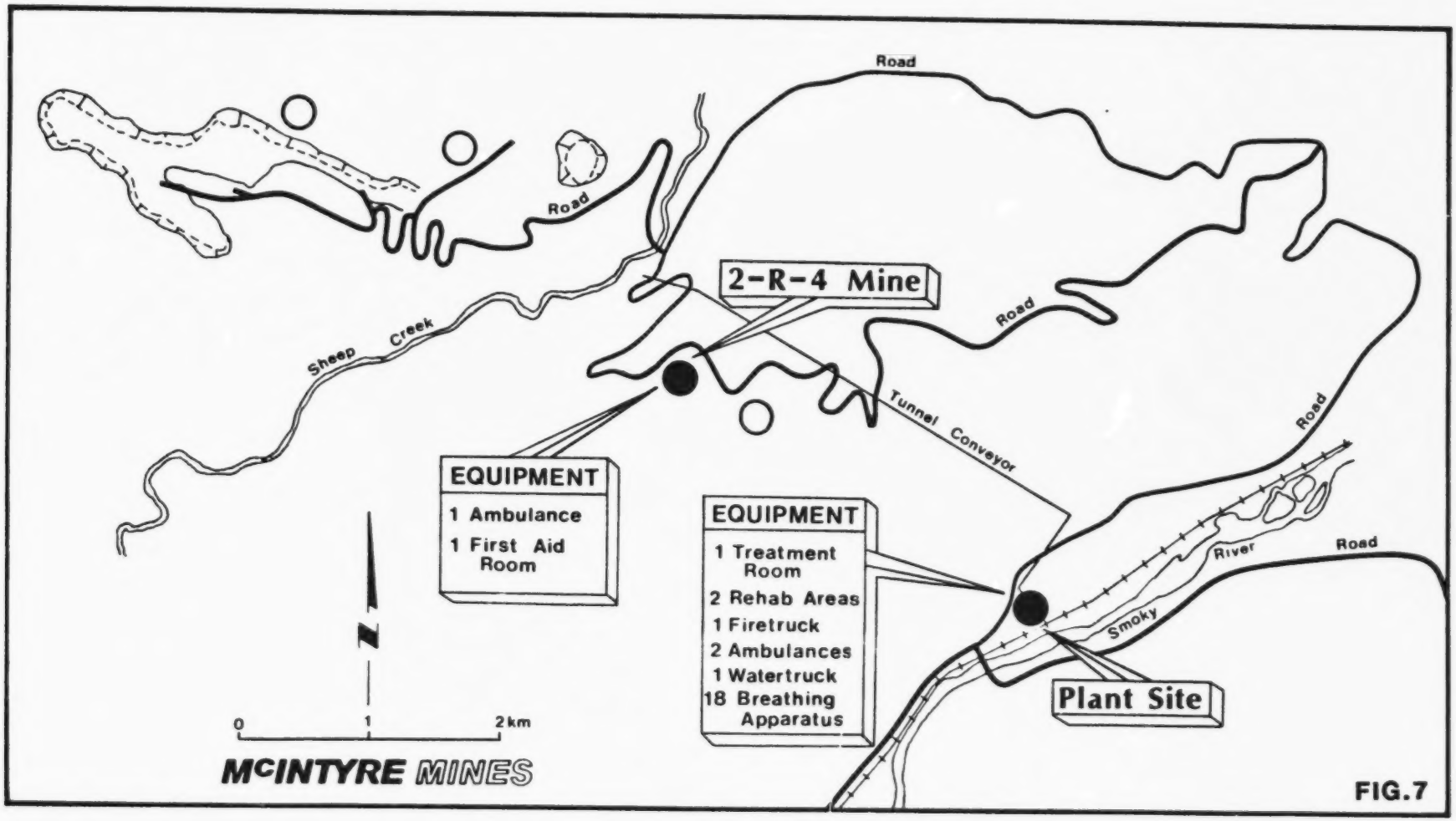

Road
Road
2-R-4 Mine
Road
Sheep Creek
Tunnel Conveyor
Road
EQUIPMENT
1 Ambulance
1 First Aid Room
EQUIPMENT
1 Treatment Room
2 Rehab Areas
1 Firetruck
2 Ambulances
1 Watertruck
18 Breathing Apparatus
River
Road
Smoky
Plant Site
N
0
1
2km
McINTYRE MINES

FIG.7

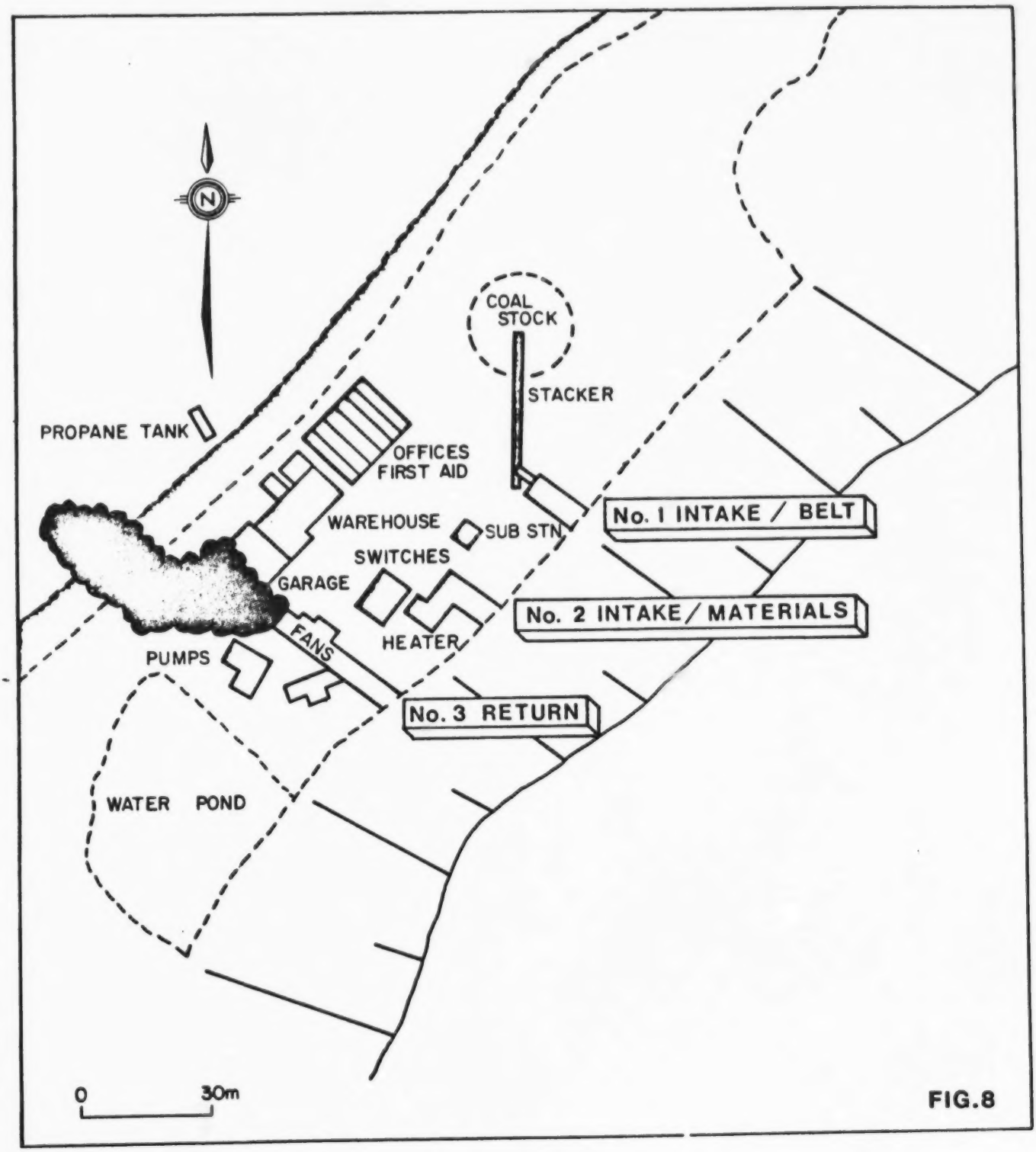

N
COAL STOCK
STACKER
PROPANE TANK
OFFICES
FIRST AID
WAREHOUSE
SUB STN.
No. 1 INTAKE / BELT
SWITCHES
GARAGE
No. 2 INTAKE / MATERIALS
FANS
HEATER
PUMPS
No. 3 RETURN
WATER POND
0
30m

FIG.8

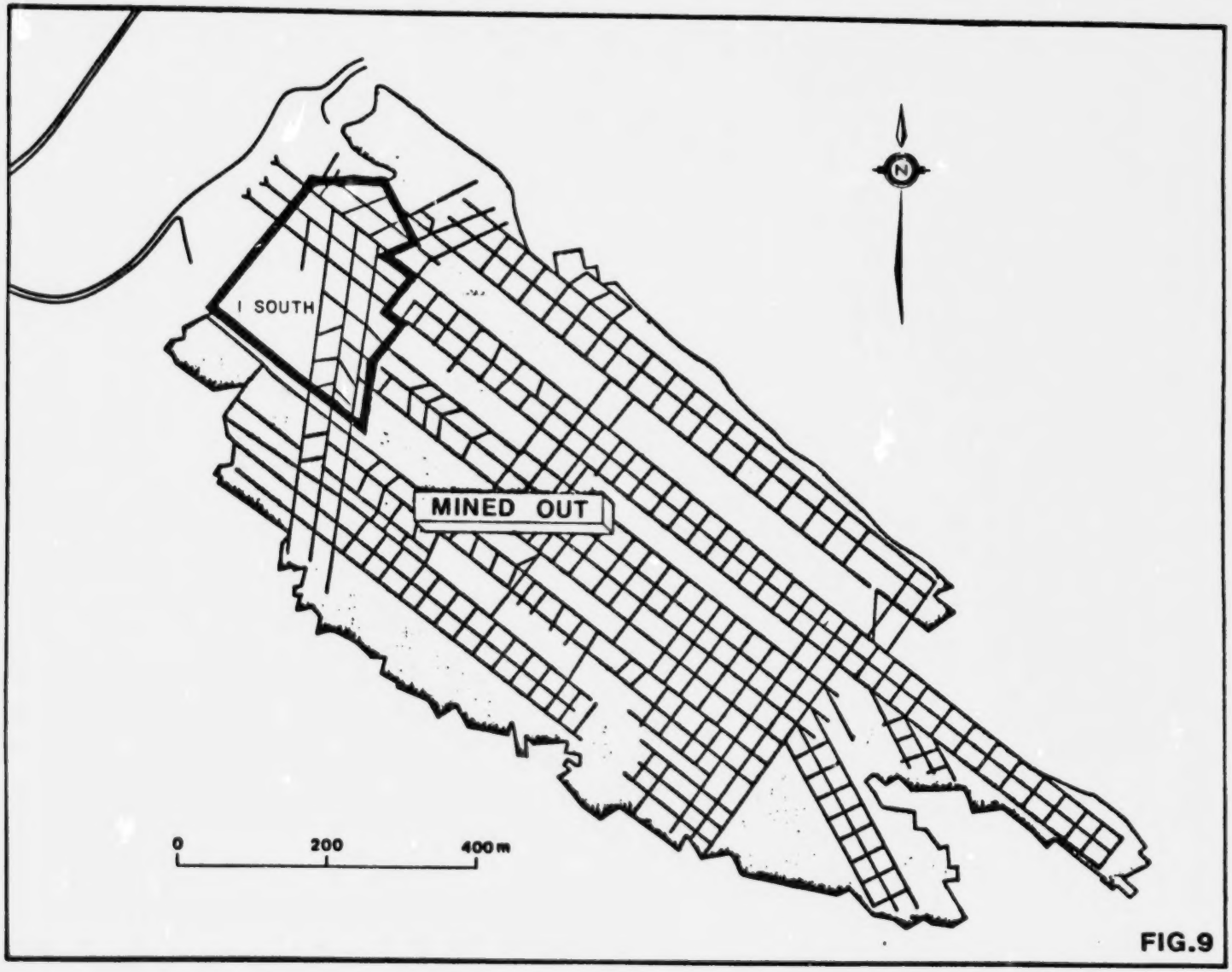


FIG.9

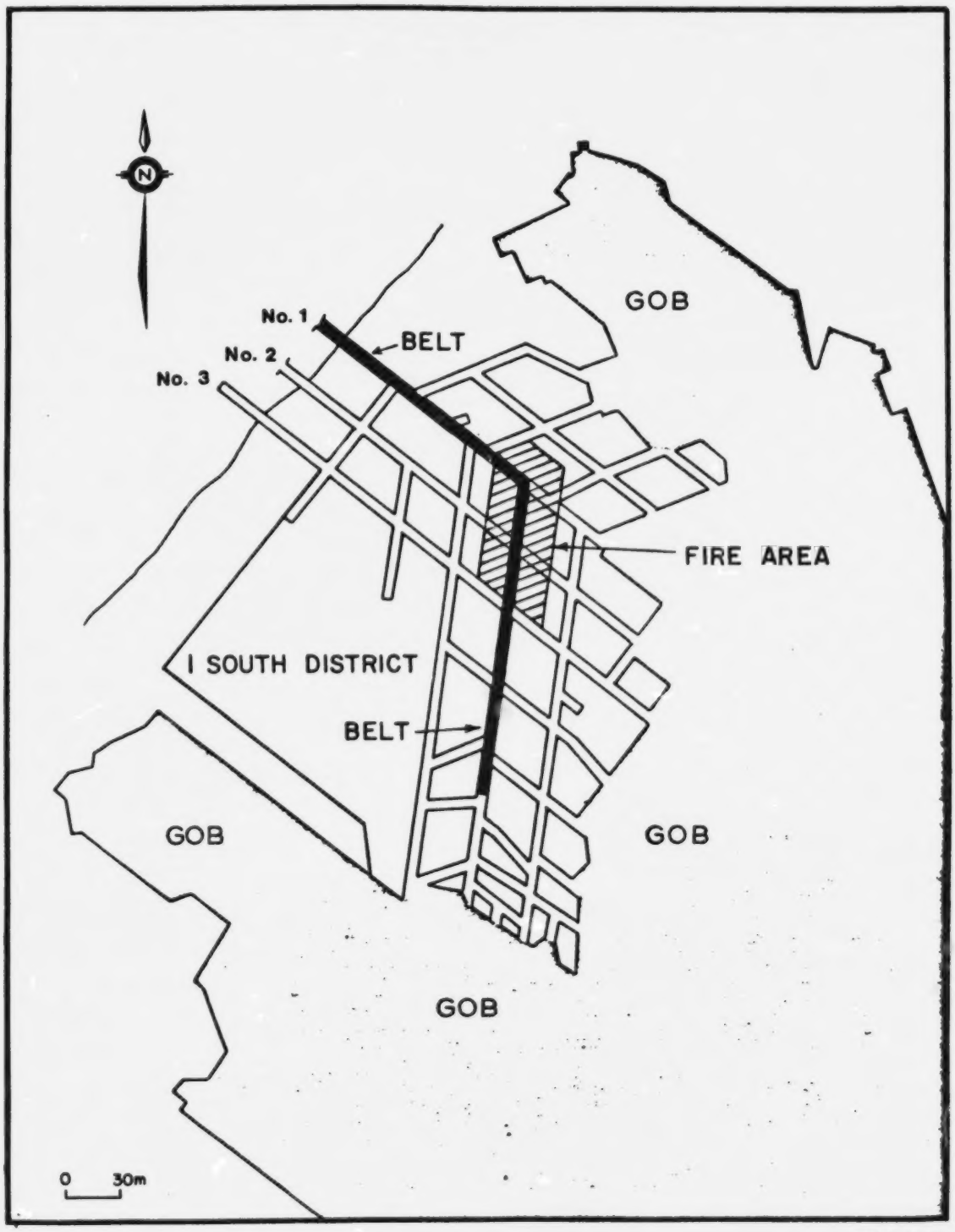

N
No. 1
No. 2
No. 3
BELT
GOB
FIRE AREA
I SOUTH DISTRICT
BELT
GOB
GOB
GOB
0 30m

FIG. 10

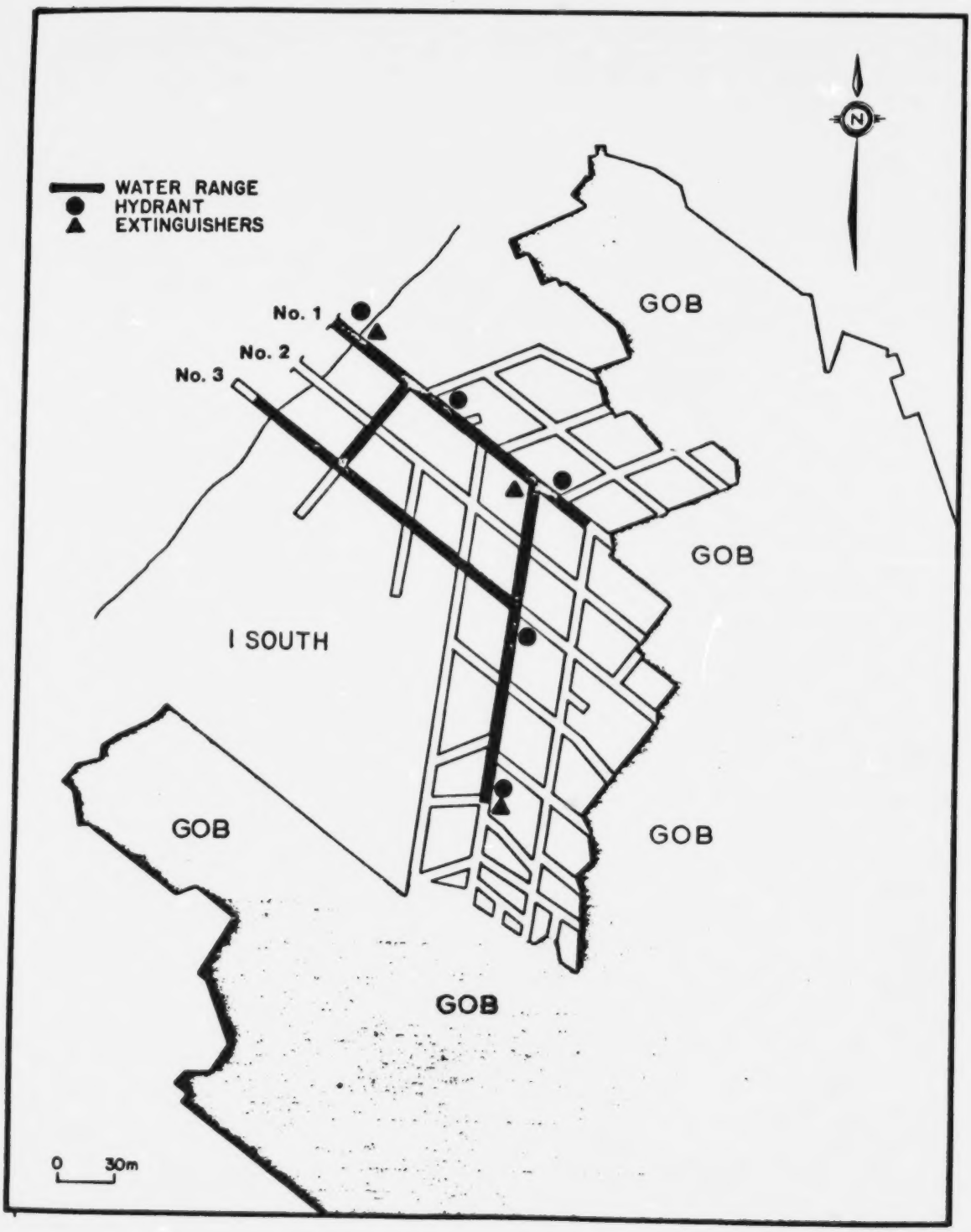

WATER RANGE
HYDRANT
EXTINGUISHERS
N
No. 1
No. 2
No. 3
GOB
GOB
I SOUTH
GOB
GOB
GOB
0 30m

FIG. 11

McINTYRE MINES

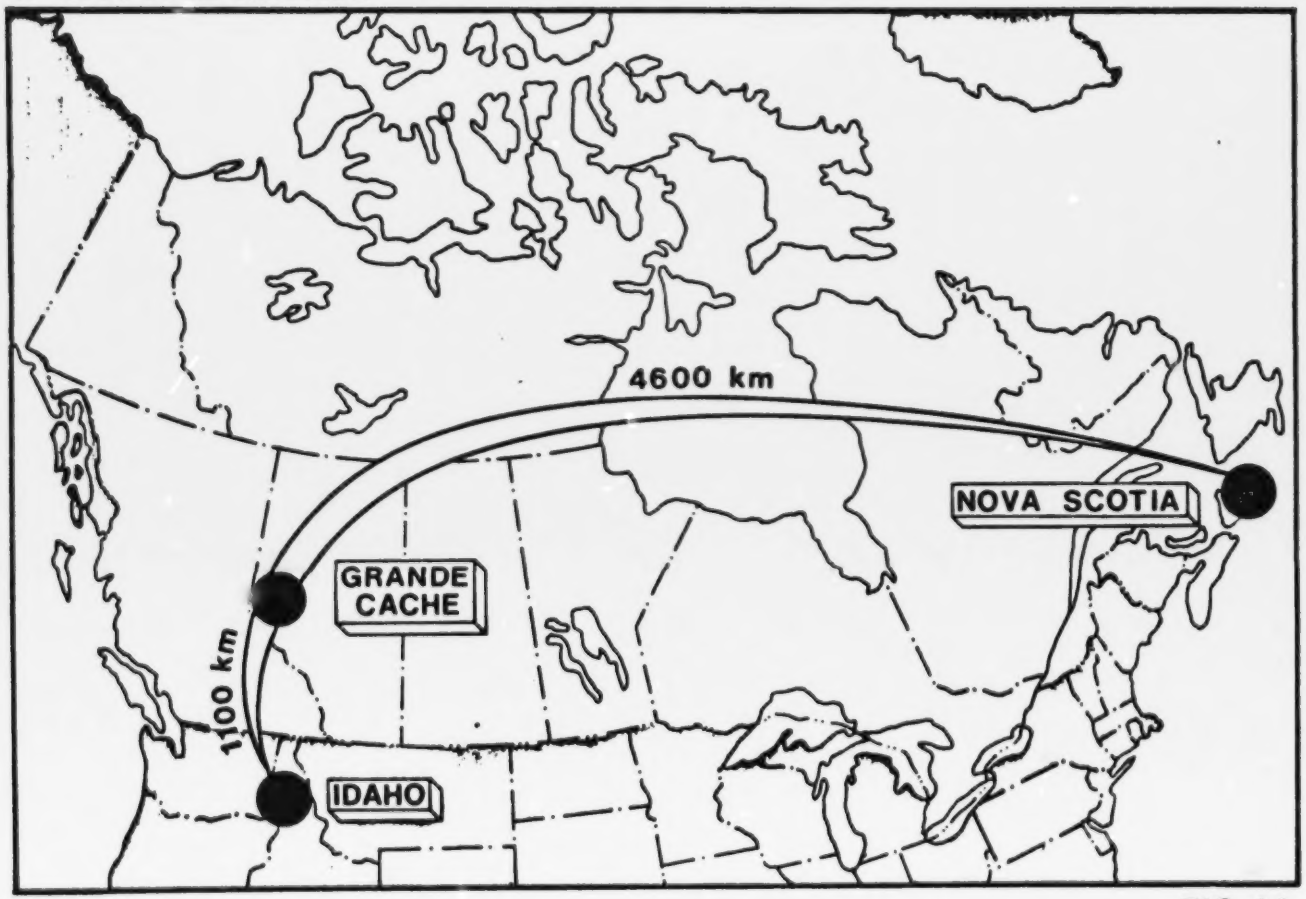


FIG. 12

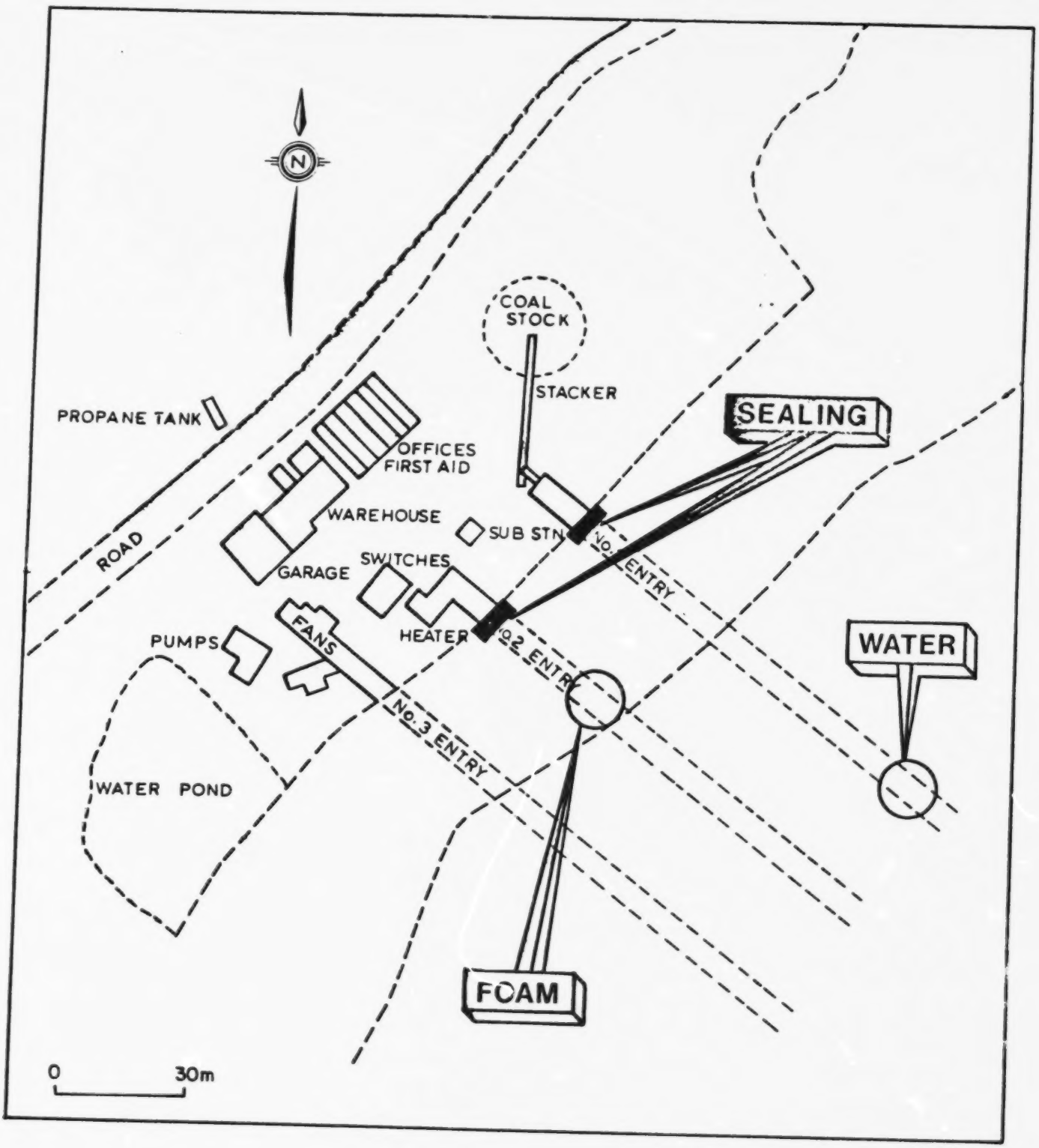

N
COAL STOCK
STACKER
SEALING
PROPANE TANK
OFFICES
FIRST AID
WAREHOUSE
SUB STN
No.1 ENTRY
ROAD
GARAGE
SWITCHES
HEATER
No.2 ENTRY
WATER
PUMPS
FANS
No.3 ENTRY
WATER POND
FOAM
0
30m

FIG. 13

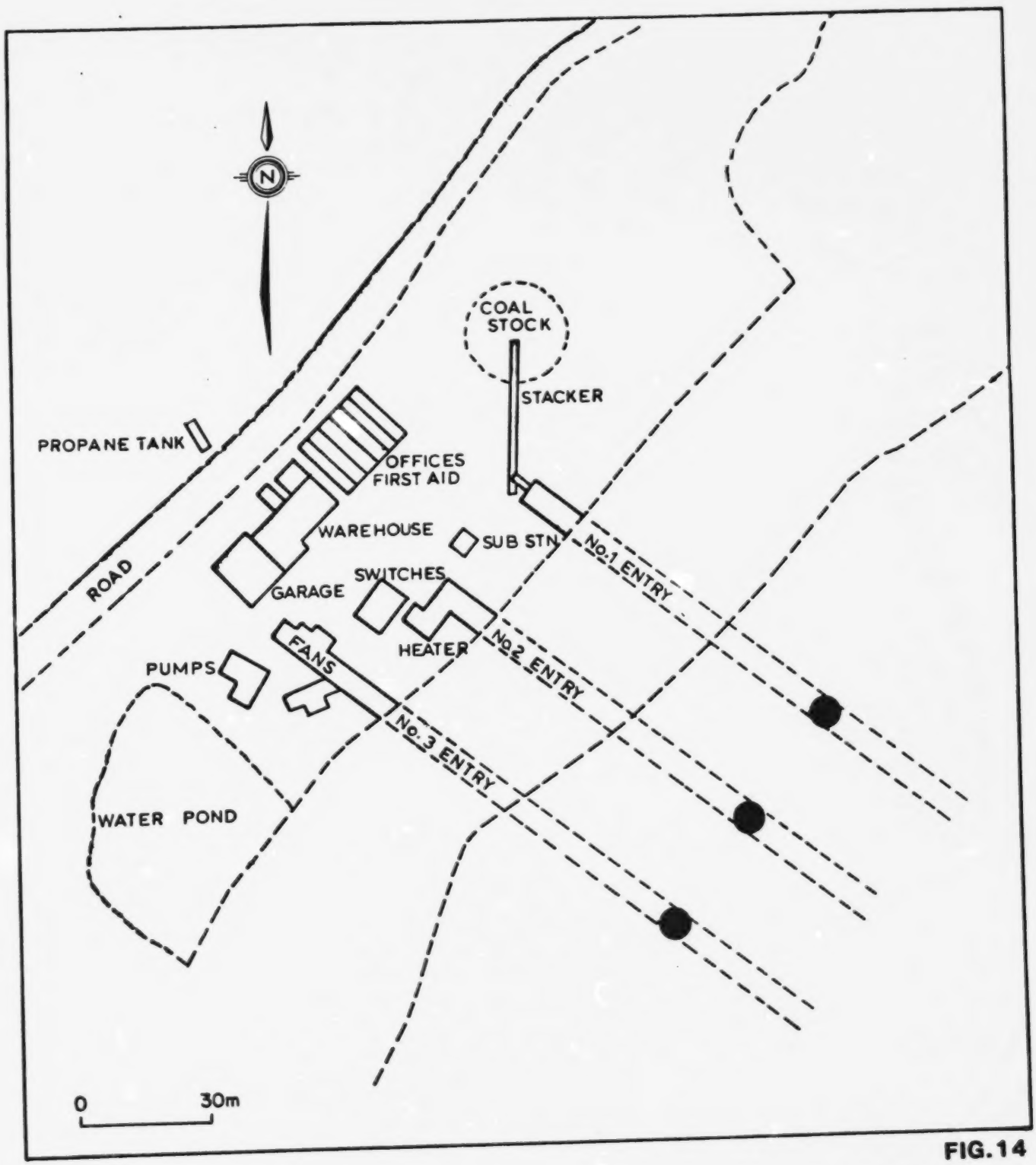

N
COAL STOCK
STACKER
PROPANE TANK
OFFICES FIRST AID
WAREHOUSE
SUB STN
No.1 ENTRY
ROAD
GARAGE
SWITCHES
HEATER
No.2 ENTRY
PUMPS
FANS
No.3 ENTRY
WATER POND
0
30m

FIG. 14

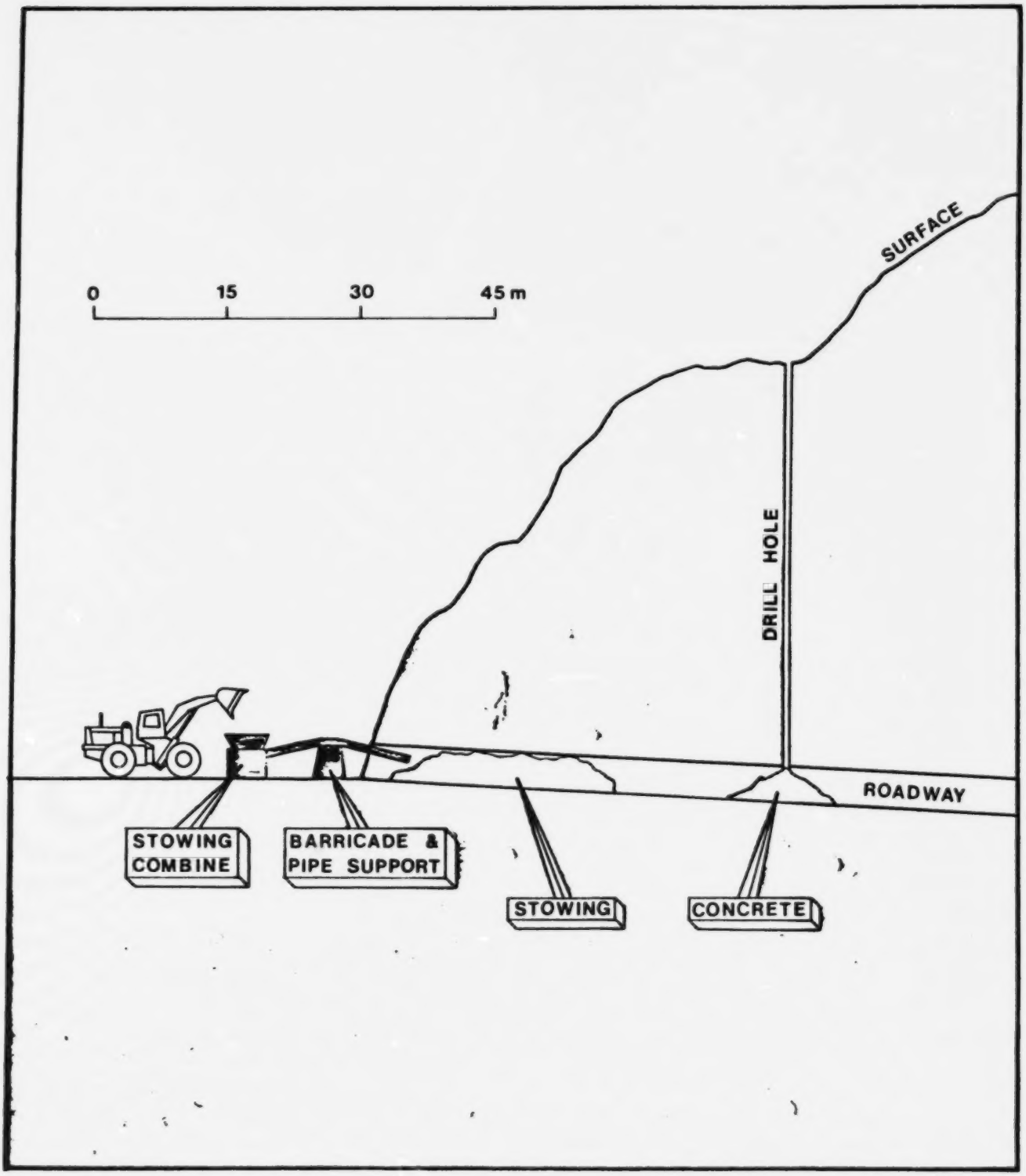

0
15
30
45 m
SURFACE
DRILL HOLE
ROADWAY
STOWING COMBINE
BARRICADE & PIPE SUPPORT
STOWING
CONCRETE

FIG.15

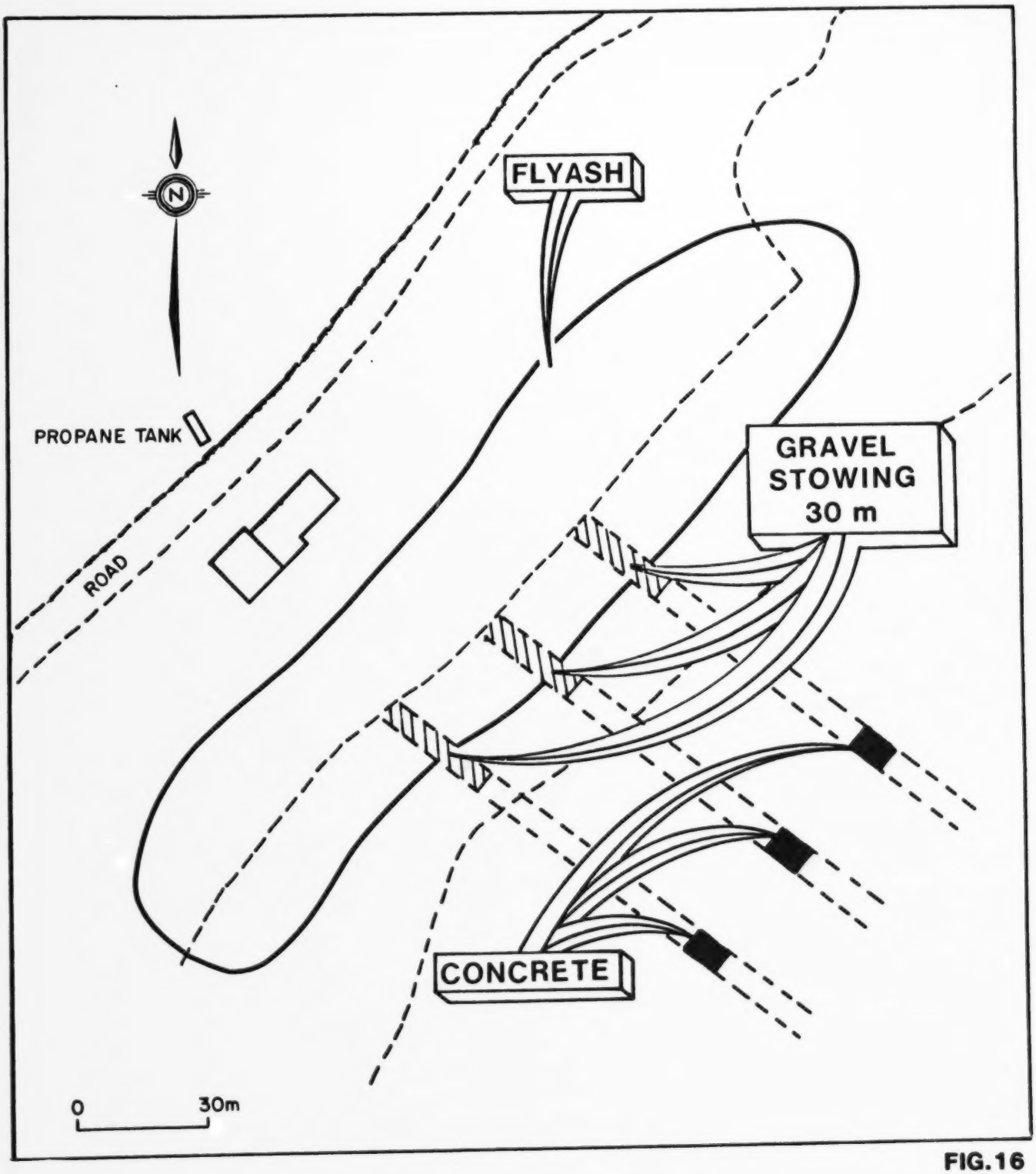


FIG. 16

McINTYRE MINES

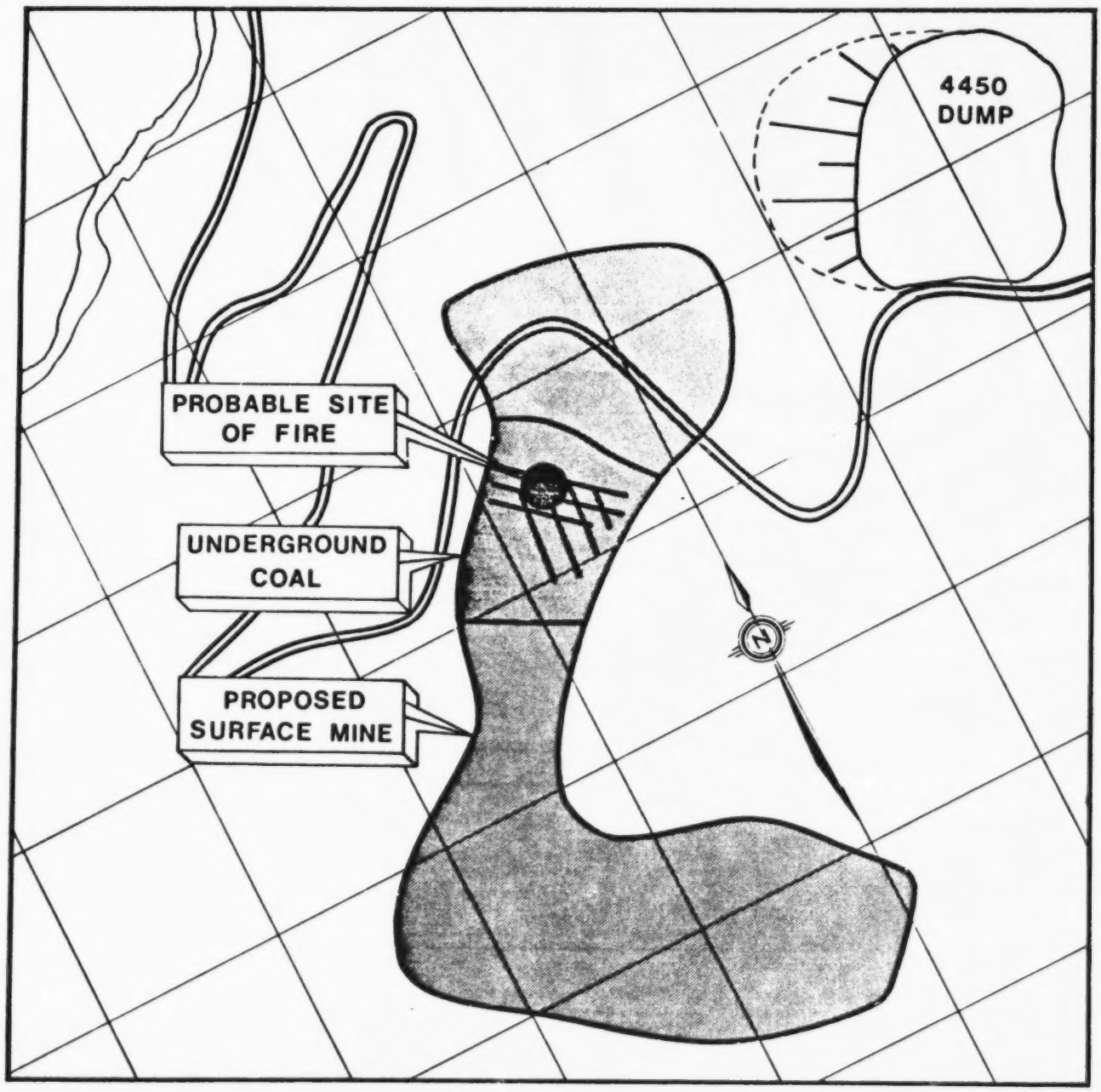


FIG. 17

DISCUSSION FOLLOWING PRESENTATION OF J.P.L. BACHARACH

Q. Why was the foam ineffective?

A. First, the type of foam that was used was for aircraft fire control and was probably inappropriate. Second, the roadways were very wide so that the foam spread over a considerable area and by the time it got to the fire it had broken down. Third, our people had not been trained in the use of foam before the incident.

Q. Do you have deputies, or mine examiners?

A. Yes, we do. We have senior foremen and foremen. They are statutory appointments requiring certification.

Q. Was there anyone travelling the mine after work had ceased, for example, on Sunday morning?

A. No. It was statutorily in compliance to have a period when there was nobody in the mine, but we now appreciate that regular inspections during the weekends are worthwhile.

Q. How does the climate affect your firefighting facilities?

A. In Alberta, we operate between about $+30^{\circ}C$ and $-45^{\circ}C$. In the winter there is a great deal of ice on the surface reservoir and we have to depend on the underground sump. We have to pump continuously through the range otherwise it freezes up, which means keeping power on to the mine.

Q. What happened when you wanted to put water on the fire?

A. The fire had damaged the power line to the pumps. We had to get into the surface reservoir, re-energize the pump house and lay a range across the surface to couple it into a dust suppression range in the outer end of the intake airway which was then used to feed the hoses. This took 45 minutes.

Q. Have you introduced any monitoring since the incident?

A. We have considered it but have come to the conclusion that the best protection is through regular inspections by observant foremen. We have increased the frequency and thoroughness of our inspections. There are many mining people who believe that the best detector for fire is the human nose.

Q. Were there any formal arrangements for outside rescue assistance?

A. No, but we knew the Idaho people and the Nova Scotia people well. We had been personally involved in assisting them with problems and when you need help, you call on your friends. One of the things that should come out of this conference, which we think the paper highlights, is that with the great distances involved in Canada, we should get together and set up stage 1, stage 2, stage 3 alert rings, so that for stage 1, perhaps we can go to Saskatchewan; for stage 2 to Ontario, who have an excellent mine rescue organization; and further afield to stage 3.

Q. Why did you introduce bench technicians?

A. The worst person in the world to strip down and attend a piece of mine rescue apparatus is a tired mine rescue worker who has just come out of a smoky atmosphere. So we looked at alternatives. Mr. Gorrie pointed out yesterday that full time rescue personnel in Europe also act as bench technicians during an incident. They turn the apparatus over. When the team members go on duty, they only have to pick up the apparatus, do an emergency test and put it on their backs. They've got trust in the technicians who are handling it.

Q. How did you implement the concept?

A. We selected six of our people and asked experienced Idaho staff to visit our mine and put them through the basic bench technician course. From the six people we picked three, who went to Idaho for further training, so that they could instruct others.

Q. What was your rescue strength at the time of the incident?

A. We were carrying three fully trained mine rescue teams and had eighteen sets of breathing apparatus. We still have eighteen sets of apparatus, but now we have forty trained mine rescue men.

Q. How did you decide that it was a conveyor belt that caused the incident?

A. Nobody has actually decided. The most widely held view is that it was a conveyor fire. We eliminated spontaneous combustion as a likely cause because our coal is not liable. We've got semi-crushed pillars all over the workings with limited air passing over them and we have never had any heatings. We think that it is very unlikely that it occurred in this case. The belts were supposed to have been stopped at the end of the working shift by sequence control. The power to the mine was left on to run auxiliar ventilation and pumps. So, the power was not isolated which would have guaranteed that the belts were off. It is possible that the sequence control was faulty and the conveyor continued running.

A. Continued

The section belt had been shortened back on the Saturday morning and there had been some difficulty in tracking the conveyor. They got it running true, then finished work and left. When you track conveyors, unless you run them for a time under load, they can go out of true again. In this case, the belt may have rubbed some of the timbers at the side of the conveyor structure.

Thus there were a number of elements which led us to believe that it was likely to have been a conveyor fire. When the fire was first noted, the electrician who discovered it and another man went into the mine and saw burning around the delivery of the section belt on to the main conveyor. Nobody can determine the real cause until we excavate the mine, or open it up.

Q. I have a couple of observations rather than questions. You had a lot of heavy haulage equipment available to you - I presume you had a dozer and so on. Did you contemplate dozing in the entrance? Or dozing dirt into the entrance? We have sealed two or three of our mines in a hurry by simply pushing the entrances full of dirt, throwing the fan out the road and filling that up as well.

A. We didn't give that sufficient thought. In fact, looking back on the incident now, we should have given that careful consideration. However, to do that you would have to conclude that it was going to be plugged up and left for some time. We tried to delay the commitment to abandoning the mine as long as possible. So we attempted to put on seals with accesses, so we could close the doors and when the fire went out, get back in that way. Dozing in the entrances was a more final solution. It could have been done, but would have meant making the decision that it was all over at an earlier stage. I think that everyone is aware of the dilemma in this type of incident. At the time, you hope, perhaps too optimistically, that what you are doing is going to work and try to keep options open for saving the mine, or getting at the reserves again at the earliest possible date. Perhaps more decisive action at an earlier stage might have been more effective. I think your comments are certainly valuable.

Q. You mentioned that the belt conveyor was well alight, was the belt conveyor fire resistant?

A. Yes, but the area around the conveyor contained timber supports, which were not fire resistant.

Q. What was the cost of this incident?

A. The biggest cost of all was lost production. The cost of the combat operation included the transport of people from outside; the cost of people at or around the scene of the incident, including electricians, mechanics and others. Then the concrete plugging and stowing. I would estimate that we probably took about 2 weeks to

A. Continued

drill the holes and put the concrete down. We had about 8 to 10 people working each day on that, which adds up to quite a number of man shifts. Then there was the material cost of the concrete, the transport of the stowing machine from British Columbia to the mine, plus people from Sullivan and about 2 weeks doing the stowing. Then there was the transport of several thousand cubic yards of fly ash a distance of 15 kilometers and a dozer working for a fortnight. When you add it all up, it was an extremely expensive incident. Bear in mind also that the reason for trying to keep this mine accessible was that in room and pillar mining the expensive part is the development and the profitable part is the depillaring. Here was a mine with all the development done, in the final depillaring stage with the shortest transport distance, and the remaining coal was that which we were most concerned about losing.

Q. How was the incident managed?

A. The General Manager and the Manager (Underground Mines) were amongst the earliest people on site and got there within an hour or so. The Mines Inspectorate were there a few hours later, getting in from Edmonton just before the road was closed. The Manager (Underground Mines) stayed on site for all of the first day until the late evening and came back on again the next morning. He stayed at the mine site with one of the Mine Inspectors and the General Manager and Assistant General Manager established an incident room at the administration office. The Manager and the Inspector handled the actual firefighting and the deployment of the rescue teams and made the on-site decisions. The General Manager and Assistant General Manager and other Inspectorate representatives were at the main office and provided back-up and communications with outside, requesting equipment, and so on.

How long can anyone act effectively in these circumstances? I think it varies from incident to incident and there is always a temptation for management people to stay on the job indefinitely, perhaps losing effectiveness after 2 or 3 shifts.

PANEL DISCUSSION

MODERATED BY

J.J. GRAHAM
British Mining Consultants Ltd.

Q. Unrecorded question on the prevention of mine fires.

A. F.J. Kock, West Germany

It is my opinion that you shouldn't exclude any area when you are dealing with this problem. I understood in these days that wood is an ideal material in this big country and it is the cheapest one. But if you especially look at inclined roadways, then you have to think about what happens if you can't fight the fire in the first minutes, or in the first hour in more reality. The fire creates pressure against the ventilation and I think that may be a reason why the foam didn't work so effectively as in other cases. Therefore, I think, especially in inclined roadways, you should eliminate all the flammable material you can. You cannot exclude the coal, that is clear, and you cannot exclude the conveyor belt. There are, of course, great differences in the material you can have in the belt, but from our last experiments we did with several materials for conveyor belts, I doubt that there is any material in the world market that will not burn. That means in our experience in an inclined roadway with a conveyor belt there can happen a fire. In the future, as in these days, early detection is important, but before the early detection, you should eliminate all the flammable material and that means eliminate wood in these roadways. That is my recommendation.

Q. Unrecorded question concerning decision making during an incident.

A. M.J. Muir, N.S.W., Austrailia.

All of our operations have involved more than one person making decisions. I don't see how you can avoid that. You could have an over riding control, I guess, and an inspector could say "that is the end of it fellows, put the lid on it". But it doesn't work that way nor should it work that way. I do believe that a manager, as such, should not be regarded as being responsible, he still is in law. As I have mentioned before, a subsequent inquiry might decide to nail him. I don't like committees, they start off making horses and end up making camels. But I don't see any other way. In our situation, we have had quite a number of these things. That is the way it has worked to date successfully.

A. J. Greenwell, MacIntyre Mines.

I would like to add a viewpoint here because I feel quite strongly about it. No matter where you go in this world in coal mining, the manager is charged with the safe working of the mine. That is his responsibility. Once he has an incident on his hands, he is in a different ball park. It is no longer the safe working of the mine, it is the recovery of the mine and the safety of persons who might be trapped. The manager

is not the person to make the decisions. The manager is there to provide logistic support to the rescue operation. There is little point in tieing your manager up in making unsafe decisions as to where rescue men should go when in actual fact, one of the more important aspects is to provide those rescue men with the equipment they need. He is the only person who knows how his mine works. That is why we feel that the mine manager is certainly involved, but he is not involved in the incident, per se. I hope that doesn't upset too many people, but that is the way we feel and that is what we are staying with.

A. C. Gorrie, United Kingdom.

I guess my comment on that question is that I think there are differences because there are different regulations that require different things to happen. But I think the bottom line is that it really doesn't matter how you do it, or which system you use, as long as you do it well. I think the critical thing is that when you get into a situation on handling any emergency, you have a plan, you try to minimize the confusion and gather the most information you can. I think any of the systems that have been discussed will result in successful conclusions. You have to do it with a plan in mind and I think that the plan has to start very early. I think that then it will work.

Q. Unrecorded question concerning legislation in relation to crisis management preparedness.

A. R.G. Peluso, U.S.A.

I think we approach it from the standpoint, and this is both the regulatory standpoint and the operator standpoint. We even add several other dimensions to it because of the way our regulations and laws are structured. We include the state people, in all the states there is a state organization that is responsible for health and safety, and the representative of the miners, who is a party. You might not like the thought of operating via committee, but in fact they are parts of that program and they have to have significant input. But the way we do it is from the conception there are regulations that require plans, plans to be generated, plans to be submitted and plans to be approved. A lot of people have asked me why do we do that, but it is a rather risky business but that is part of the way that we do business. But it is the planning from the conception, it deals with all the aspects of health and safety in that mine, of which evacuation and crisis management becomes a part. Maybe it is under a different name, but it is there. So we in fact have a program of planning prior even to the first mining of any material. That is the way we do it.

A. C. Gorrie, United Kingdom.

John did pose this question yesterday and I did attempt to answer it by looking at it through the regulatory field because as I attempted to explain, crisis management, in our view, starts off with the safe guards of any non-hazard. Now the way we tackle this in the United Kingdom is by a very detailed and tight system of legislation. I am sure that most of you at some time or another have seen the mining safety legislation, or parts of it, in the United Kingdom.

Our view of this type of legislation is that ultimately it is the employer or the mine owner, who has got to provide the finance and the resources, which is going to put that into operation, and also it is the workers representatives and the trade unions who are going to put it into force. Unless we have the full co-operation of both parties, we recognize that that legislation is not worth the paper it is written on. So before we start off any way down this far, we go through a very, very detailed process of consultations to achieve this level of co-operation. That is very slow. It takes years, literally to go through this process and as I gave the example yesterday of the filters in the self-rescuers, the carbon monoxide filters, we are still a long way off getting legislation in. But we have had these things in for 15 years. You couldn't get any slower than that, but the thing is that having achieved it voluntarily, there is less pressure coming in. A review of the electrical regulations, a review of the ventilation regulations, we have got limited resources as well to deal with this.

But quite clearly, our view is that crisis management is based on stern legislation and stern legislation is based on the co-operation of all sides of the mining industry. So that is where we start off with the crisis management. It would be nice to think that the level of management would prevent mine disasters, but we know that it won't. I always like to think that the last one that I had to deal with, will be the last one. I know that I am always leary of this and I know that we have got to be prepared. The basis of our preparation for that is a sound crisis management organization. One the basis of the colliery manager or the mine manager's scheme of emergency organization, which was anticipated again 50 years ago when this committee on crisis management, they didn't quite look at it in that view, sat down and said what is the problem and what is the type of solution that we are going to have, and they said that the best solution that we can have is not only a skilled rescue service with excellent equipment, but also the ability to use that properly, based on a skilled management team. That is the structure in which our crisis management works.

I gave two examples where we saw it being exposed to tremendous pressure during the course of 8 days, and it withstood it. And the most recent case where good luck, good fortune had a lot to do with it. But in addition to that, we have this organization for crisis management, which in this occasion worked perfectly and 41 men were in hospital within just over two hours. I think myself

that crisis management starts off with this co-operation and legislation, but is must be backed up with a sound organization.

Q. Joe Burke, Nova Scotia.

A general question concerning increased mechanization on faces and in particular installing stowing machines in return roadways and the hazards that may be associated with that.

A. J. Bacharach, MacIntyre Mines.

I don't know whether this is really the forum in which to discuss this issue because I am quite sure that the corporation's engineers and management have given very serious consideration to all the implications of adopting this system. As an outside observer, I would think that provided the proper safe guards have been put into the system in terms of cut offs at certain methane levels, that an effective way of stowing the rib side tail gate end of long panel advancing longwalls, can only be a step forward and that the hazards inherent in systems which require manual placing of packs at tail gates of seams with reasonably high gas, that the proposed system that you describe which gives a tight pack and enables it to be placed on well in advance, as close as possible to the brushing, is something to be commended. But I repeat that a full evaluation of the system would require a lot more consideration than we can give it at this time. But the idea seems to be one well worthy of application.

A. J. Graham, British Mining Consultants Limited.

I have a point myself on that. There are some safe installations of stowing machines in return roads in the United Kingdom and the safe guards that John Bacharach has mentioned are strictly controlled. But the alternative approach is perhaps to consider pumping the material down the main gate, if it is a longwall face, and putting on from the inbye end, as it were.

A. J. Greenwell, MacIntyre Mines.

My own feeling is that I am fully in concurrence with John in having some one individual on a shift doing that work rather than a team member because his whole attention is on that equipment. He is thoroughly trained in it, he knows what to look at and can make a proper assessment. The individual who is going to use it or wear it, as had been said, could be too tired or not sufficiently familiar to know the tests that should be made and the things that should be observed in making sure that that is in proper working order. I think that the technician is invaluable there.

A. George MacPhail, Ontario.

In Ontario, we have adopted the principal or the procedure where the individual team member must run through his own series of field tests on the apparatus. We have broken down the tests into field test-, which must be done on the job before being used and station tests, which a mine rescue training officer must perform on every piece of equipment once a month. The field tests are simple. The men are trained, we spend a lot of time from the basic training on through and every training session there is a lot of time spent in the field testing of apparatus, we make them repeat it and repeat it and repeat it until they are thoroughly familiar with it. We took the attitude back in 1947, as a result of a fire in Quebec, when teams from Ontario were asked over to help out. At that time there were four different systems of looking after the apparatus. It was very poorly done. We were not too proud of what happened at that time. The result of that was that the attitude was that each man, his life depended on that apparatus. The same thing as a person who is packing his own parachute, maybe that has been changed, maybe the air force doesn't do that any more, but at least we have insisted that the person himself must test his own apparatus. In the event of a fire, our training officers from the adjoining areas or from some distance away are immediately brought in to assist and they are the key persons. Their job in the event of a fire is mainly to supervise the action of the teams, to observe and carefully check the men in making their field tests and making sure that they are in proper condition before they leave the surface fresh aire base. I realize that there are many different ideas on this subject, but we feel that this had been successful, it has worked and we have had our mine rescue teams in operation many, many times and we have yet to find any real probelm with this system.

A. F.J. Kock, West Germany.

I can answer it only from our regulations. We have for every rescue team so called apparatus attendants, and there is one main attendant, you say a technician. I gave you yesterday some figures about the average strength of our rescue teams, about 80 men, there are in this figure of 80 men an average of 10 apparatus attendants. We prefer that these men not only have the function of technician, but also as rescue men, because we believe that he understands his responsibility much better if he knows the problem from wearing the breathing apparatus himself. The figure is so high because we want to refresh the apparatus down in the pit in an emergency case, at the fresh air base. Therefore, you need more than one person. On the other hand to what we just heard, it makes sense that all the rescue men may be not able to do this in the same accurate manner that is necessary. If we speak about testing a breathing apparatus, then we think about using special testing devices. That is easy to explain. With a BG 174, as you know, is a special testing device. What we do, and it is a regulation, we test the tightness of the apparatus with these testing devices once a week and we test all the functions of the apparatus once a month. If you have tested in these short intervals, then we can use the apparatus without testing again before an emergency.

As was mentioned in the example from Alberta, if the breathing apparatus must be transported to the mine site, the apparatus attendant would have to test it again before the team is sent in with the apparatus.

A. C. MacDonald, Nova Scotia.

Our system in Nova Scotia is similar to Ontario's. From my years of experience, and they go back quite a number of years, I have always had the last look and touch of my own machine. We find that that system here works very well. In our past number of incidents, we never had any problems with it. I agree that if a person is going to jump out of that airplane, he should check his own parachute. Our system of testing, our supervisory people, our attendants, they look after that equipment on a monthly basis. The equipment is all checked out. But when the emergency comes up or arises, the mine rescue people, the team members, they test their own equipment. They take it out, they test it, they prepare it all and they get themselves ready to go into the situation.

A. J. Greenwell, MacIntyre Mines.

If I came across in the wrong way, I am sorry. Don't misunderstand. Our mine rescue men do the field test on their equipment before they put it on and go into the mine. All that I wanted to say was that in our remote situation, with our limited labour force, we have to be very selective in our skills. We are aiming to enhance the skills all the while. Hopefully, the instructors that we now have got certificated, although be it not Canadian certificated, will be training further people and therefore we will get an all around enhancement of skills out. But I do admit that when I pay $250.00 to have my car given a winter service, I don't check the radiator to see if they put antifreeze in.

A. J. Merritt, British Columbia.

Myself, I was thinking along the same lines. I was thinking after the continued effort, if you have one team after another coming in, I do feel that you should have some base attempt to go over those machines with the crews when they pick them up to check to make sure that they are satisfied that it is in running order. But if there are any repairs or any basic work to be done, your base man should be there doing it.

Q. I am talking about the fire that they just had in No. 26 Colliery. You have six dragger teams there, four at Lingan and three at Prince. Would you say that if the fire is burning for six hours, that all these teams should be standing by? You don't know how long this fire is going to last.

A. That was 10 teams that were all there very quickly.

Q. Yes, but what I am saying is do you think that everybody should be on standby from the other collieries because you don't know how serious this might turn out to be?

A. I see, it is a question of the standby calls to the neighboring collieries.

Q. That is right. There were a couple of more teams in Lingan but there was nobody on standby. What I as asking is do you think everybody should be on standby when you have a pretty bad fire like that?

A. As I understood, I would say yes, they should stand by. Why not, what is the problem?

Q I don't know, maybe they can't afford the money.

A. F.J. Kock, West Germany.

What we do in a situation similar to what I understand to be the situation at your fire in No. 26, we call, if we can, many more teams in the first moment than we can need. We let the teams wait for several hours until we are quite sure that we have good results in the fire fighting and then we can send one or two or more teams back. But we are very happy to have in the beginning of fire fighting more teams normally than the manager can imagine that he can use. When we are first called, my first question is have you alarmed any of the teams as yet. And as soon as I inform the boss about the situation, I will call more teams. Not only from one colliery but from the neighboring collieries too. There is not a question of money in our coal field, that is legislation. Every operator is obliged by law to help the other colliery in an emergency situation.

A. C. Gorrie, United Kingdom.

It has been some time since I was involved in this type of logistic situation. But if my memory serves me correctly, when you are planning on a two hour stint in a rescue situation, with a rescue team standing by with another travelling and another possibly on the surface getting kitted up, it works out that approximately 4 rescue teams for one in operation. This works out on a two hour basis with an eight hour shift for the rescue team at the mine. That is for any one group of rescue workers. If the incident is of major proportion and you are using more than one, then, of course, you are getting into a very, very highly organized logistic situation, bringing managers from different mines and possibly from different parts of the country. So it would not be unusual for 4 or 5 rescue teams to be standing by with one in use.

Q. R.G. Peluso, U.S.A.

In the United States there is an issue that is presently being discussed. It was mentioned yesterday by Mr. Kock. I would like to know from the members of the panel here and anyone else in the audience that their thoughts are with regards to the use of self-contained oxygen self-rescuers as part of the mine rescue team auxiliary apparatus.

A. G. McPhail, Ontario.

On only one occasion, to my knowledge, was an oxygen self-rescuer used due to a malfunction of the breathing apparatus that a team member was wearing. He was able to convert to that and come back to surface with his team. We discussed this at our meetings quite a few years ago when we first adopted the Oxy SR-45 and it was unanimous amongst our training officers that 3 pieces of such equipment would be carried by each 5 man operating team.

A. M.J. Muir, N.S.W. Austrailia.

Regarding the self-rescuers, we, in Australia, where each station is different, we agree to disagree generally, but in my district we wouldn't carry the self-rescuers. The weight problem would, for one thing, irritate us. We do insist that all team members carry filter self-rescuers in case they get separated from their unit. But we do carry, what we call two therapy units which is an open circuit unit made up of the bottle we use in the BG 174 with a regulator and a demand valve. Also, we carry a recessitator and we do insist on carrying a stretcher. This is what we call in Australia minimum equipment. You can use these units to actually recover people, if you have to recessitate them and you can use them as escape units as well as the back-up on the bottles. But generally to carry the self-rescuer when you have got a BG 174, we would consider it unnecessary.

A. R.G. Peluso, U.S.A.

I guess I didn't say what we do in the United States when I asked the question. We only use them for escape purposes. We do not use them on the mine rescue teams, but that issue is being discussed with much enthusiasm right now. So that is why I wanted to get a feel as to how the other countries treat it.

Q. Malcolm Leadbeater, Nova Scotia.

The question I would like to ask about self-rescuers is how often do they check them? I know here they check them every six months. We do carry them on our belt. They could be banged up, they could be leaking, we don't know if they are leaking. If we did have an emergency and we had to use them, they are no good to us. Are they the best rescuers that you can get?

A. R.G. Peluso, U.S.A.

I can only tell you what we do in the United States. We use both the filter self-rescuer and the self-contained self-rescuers. There are manufacturers requirements on each of the devices and we basically require that those manufacturers recommendations be met. With regard to the filter self-rescuer, we did in 1978, require that beside the regular daily inspection where you look at it, that every 90 days the filter self-rescuer be weighed and that information be recorded. With the filter self-rescuer, if it picks up moisture, then it becomes inoperable. You can pick that up by weighing it. There is a 90 day requirement. The self-contained self-rescuers, there is a daily inspection requiremen and there is also a periodic inspection and a record made of that periodic inspection. Again, this is based upon when the manufacture gets an approval, he will ask MSHA and NIOSH to approve an inspection program. Whatever that inspection program is, is what is accepted. I can tell you for the chemical self-contained self-rescuers there are two different types. One has an indicator, the indicator serves as the daily inspection, plus the periodic inspection and for the one that doesn't have an indicator, every 90 days you have to either submerge it in water, or put it in a pressure tester. Either one of those two. If you store it, then all you need to do is do that annually, but with the other unit, you just look at the indicator and do an annual pressure testing method.

Q. F.J. Kock, West Germany.

Have you made in the States a decision as to what kind of testing you should do besides a daily inspection on bottle style oxygen self-rescuers?

A. R.G. Peluso, U.S.A.

I guess I should have gone on to explain what the bottle oxygen self-contained self-rescuers requirements are. These again are the manufacturers recommendations and they are primarily checking the seal, checking the guage to make sure that the oxygen is still maintained. I think the issue that Mr. Kock raised is whether that procedure is going to be acceptable as time goes on. I can say two things. The units that we have tested have functioned. The Bureau of Mines has a 5 year program set up where they will, on an annual basis, pull from different mines 100 self-contained self-rescuers. These self-rescuers are going to be readily available to the miners. Something they would use if they had an emergency. They will take 100 of these and replace them. They will take the 100 and they will run tests on them, both machine and man tests. I think that experience will answer your question. I have to say one thing before I leave that answer, and that is that the concept of everyone here in testing bottled oxygen units is predicated here on their experience with four devices. You do th every month or you do this twice a week, or whatever. It is critica to understand that when you do that, you are actually using the device. With the other devices, they are not used. They are to

be readily available. So the question becomes if you start to do these tests, and you use them, is that a better option than leaving them and on some periodic basis looking at the critical parts of them. I only throw that out as a point of consideration because I think normally everybody feels satisfied that they have tested something and it works. But you have to realize that when you tested it, you actually used it and when you use something, you wear it out.

A. C. Gorrie, United Kingdom.

I know that the question is about the detail of testing, but what I really think he wants to know if when he uses this self-rescuer is it going to do what it is designed to do. All I can give you is the U.K. experience in this because, George MacPhail and I had a short debate about this the other day. The statistics that I quoted to you were that in the 15 years since we have introduced the self-rescuers generally throughout the United Kingdom coal mining community, and incidently, throughout the whole mining community now, hard rock as well as coal mining, we have not lost any lives due to underground fires. In the 15 years prior to that, we lost somewhere around 150 lives. I am not saying that the self-rescuer is solely responsible for that savi of life, far from it. The position is this. The provision of the self-rescuer in the general basis in the United Kingdom, does form a very important part of our Crisis Management Organization. As far as we are concerned, we are fully committed to them. The procedures that I use for testing are such that I know of a recent serious case where the self-rescuer was being used where serious problems were encountered. We often get the situation where they cannot get it out of the case, but the refresher training that the workmen have does take care of situations such as this. What we are concerned about is that they know how to use it when the situation arrises and this, of course, does involve very careful training. Are they aware of the fact that when they are using that equipment in anger it is going to get very hot. Do they know how hot it is going to be and are they adjusted to this sort of thing. These are the sort of features that we are now building into our refresher training so that we can simulate, as near as practicable, the situation that is likely to require. His cap lamp may have been blown off, so that he is dealing with it in the dark. Does he know how to get it off his belt and out of the case in the dark and that sort of thing. It seems to be working.

A. F.J. Kock, West Germany.

I must give a very short comment before we can leave this question. Some of you know that we, in our testing station, are very familiar with testing the self-rescuer since 1950. We are testing not only the devices that are on the pits, but also the devices we get from the manufacturer and we think that it is necessary to do so. Therefore, we know of some failures that may have happened in the production. The manufacturers are very satisfied that we do so. That is an additional testing procedure to what the manufacturer does. I am very glad to hear in this audience that

you mostly are very satisfied with the BG 174. I am satisfied too. In my opinion, it is an excellent breathing apparatus. But as you know and as I know, there must be very accurate testing. That is a condition so that you can trust the apparatus. We had the same experience with self-contained self-rescuers that we introduced 15 years ago in our potash mines for all the miners because in our potash mines there is a danger of C02 outbursts. From the experiences in these mines, we feel that we should do the same testing procedure with new oxygen bottle devices in the same way until we have more experience. Therefore, we are very interested in the results of the Bureau of Mines and we are looking in the same field, we will do it in the same manner. But at the moment I would advise that you test them as you are used to doing with the rescue apparatus.

Q. Paul MacDonald

It is the small metal mines that interest me, in particular the actual recruiting and motivating of teams. I wonder if Mr. MacPhail might be able to give us a word on that. Also, another question I would like to have some opinion from the panel members on the use of rescue competitions in a simulated crisis as a means of keeping a team up to date.

A. George MacPhail.

In almost all of the mines, mine rescue has become a stepping stone to promotion within the organization. I would say that all of our shift bosses and all of our foremen have, in their earlier years been members of the mine rescue team. This, in one sense makes it a little easier to recruit the men. But I would say that in every mine, our mine rescue organization, mine rescue teams have reached a point where it is a privilege to become a member of the team. We have very, very little problem in recruiting men. In fact, we have waiting lists in most mines, so that the mine, the company itself, do have a choice. They can pick and choose the men they want to have on their teams. Once they are on the team, even in their training program, their training periods, it separates the men from the boys, leadership capabilities show up and from that, I know for a fact, especially where we have had teams being used in a fire, that those team members invariably go on to become senior mine personnel. There is a small bonus, a mine rescue bonus, which is paid monthly to the members. Some of it is based on just a flat daily rate, another is paid on a percentage of their wages. It is not enough to simply attract a man simply from the money end of it point of view. But there is a comraderie, an association, a build up of a fraternity, actually, and we do have a lot of co-operation amongst the team members themselves. We really don't have a problem in encouraging men to become members of the team.

A. R.G. Peluso, U.S.A.

A while ago, maybe two years ago, we put together a program. I guess we didn't realize what we were doing. We called it Mine Emergency Response Development. But basically I think it is a crisis management course. We put it together for our district managers, both in coal and metal/non-metal. If anyone is interested in that course, I would be glad to talk to you or send you a copy of what we put together.

Q. J.J. Graham, British Mine Consultants Limited.

Who would like to comment on rescue competitions in other countries? Could we have a comment from Poland about that please?

A. Dr. P.A. Krzystolik, Poland.

It is not my job but I can say that we have regular competitions. It is obligatory for each team from the mine. Each month they have such a competition in each district station. There are all types of preparation for the rescue worker in the mine. There is special physical training and so on.

A. R.G. Peluso, U.S.A.

In the United States we have training by the teams on a regular basis, a couple of time per month and we do have competitions. We have local competitions, area competitions, state competitions. Every other year we have a national contest for coal and for metal/non-metal. It alternates. This year it was metal/non-metal and it was in Los Vegas and next year, it will be coal's national rescue contest, that is first aid also, and it will be in Kentucky.

Q. Bruce Stewart, Nova Scotia.

In recent years, we have seen the introduction of better communication systems for mine rescue teams. We have seen the introduction of real time status monitoring and environmental monitoring equipment. We have also seen the availability of relative quick turn around combustion product analysis systems. All that information is funnelling down to a fresh air base, who in many cases now are communicating with rescue teams. It seems to me that there is a terrific strain on your co-ordinator and it may change, in fact, some of the ways that you conduct some of your mine rescue procedures. I would like to have the comments of various panel members on how the recent changes and the availability of much greater levels and detail of information during rescue operations changes the way that you actually perform the duties?

A. C. Gorrie, United Kingdom.

In the preparation of the papers, it wasn't what we should put in but really what we could afford to leave out, because this is such a vast subject and really one would have liked to have warmed up the paper by dealing in some detail with aids, not only to crisis management but to the prevention of crisis generally. My priority in dealing with that aspect of the subject would have been communications and environmental monitoring. The information that comes from modern systems of environmental monitoring in both these fields. Our most recent experience has been that these first class system of communication that take from the coal face straight through to the surface control room, are absolutely desirable in the crisis of any management situation. In this incident that we give you about which described as a case study, there was no doubt about receiving the message in the surface control room virtually within seconds of the incident having occurred, that control room being able to set up the whole control procedure, having police, ambulance, to get that thing going, did benefit the casualties without any doubt at all. The information system that is coming forward is obviously making the crisis less. It is reducing the level of the crisis because people know just exactly what the problem is. I don't know about your experience but mine has always been that when I knew what the problem was, then usually the solution was fairly self-evident. John gave a beautiful description this morning of a situation where you are playing in the dark. We are going to get more of these. That is the one where you have the real problem. The information coming forward certainly makes it less of a crisis.

Q. Joe Burke, Nova Scotia

I look and I commend the work that has been done on the part of the draeger teams. We have teams here in Nova Scotia that are second to none. But the thing that gets me is I look at it and I say the bare faced miner. What has been done for the bare faced miner, who is the first person at the scene in most instances, that fight fire. I think that something should be looked into or do you have anything that is being done in that manner?

A. F.J. Kock, West Germany.

I agree if you say that it is necessary that the regular work force has to do the first steps in fighting the fire. The rescue team brings up the second step. That is our opinion too and therefore we do a lot in training of the work force in all the fire fighting methods. A detail we spoke about, spark ignitions, gas ignitions in combination with certain machines. Normally the rescue team come too late and therefore we made special training for the operators of the machine and we built a facility with propane flame that looks very similar to what in fact can happen. We trained the men with an extinguisher on the machine not only with automatic devices but also with hand held extinguishers. I spoke to a few of this audience about problems we had in the last year. I gave a figure of about 7 gas ignitions in headings. We are very glad that we can add that the men in the heading in 6 cases could extinguish these gas flames very easily and very

quickly and only in one case were they unable to control the incident. But that was a special case. It was not a question of the men and perhaps it needs too much time to explain this special situation. I agree, this is the main point in the field of prevention that the man at the face on the machine can do the right fire fighting method immediately. That is the main point in training.

A. Dr. P.A. Krzystolik, Poland.

In Poland, because of the ignition of methane by frictional sparking, we also conducted training of fire fighting for the underground personnel, especially for development drivages and longwalls. At three gassy mines we have constructed surface galleries in which we have methane fires and the aim is that the people are familiar with such fires. As we stated, in some cases the crew from the driving machine escaped. The fire was very low in the first stage and when they came 60 minutes later, it was too late. So we also have such experience that the first time is a very important time. I know of at least 3 occurences in which the fire fighting by the crew was absolutely effective.

A. J. Merritt, British Columbia.

On that same subject, in the paper that I presented earlier, I mentioned about the survival mine rescue training and I think it would be along that line. Both our Coal Mines Regulation Act and the Metal Mines Regulation Act in B.C. require that every person working underground be trained in survival and rescue procedures in which there is a certain amount of training and fire fighting and so on. But they are taught to be able to know how to either escape from the mine or get themselves into a position where they can be safe until such time as a rescue team comes in. That is part and parcel of the manual that I had here. Survival Rescue Training.

Q. I have a question dealing with information transfer. It seems that the Europeans on the panel are very much aware of what each country is doing, even to the point where Poland knows that a piece of sophisticated equipment is going through their territory and is able to lay their hands on it. I am wondering is there an organization, a formal organization or an informal organization within the European communities that allows for the transfer of information, the translation of information?

A. F.J. Kock, West Germany.

Yes, there is a Committee in the European Community. It is called Fire fighting and rescue questions and in this committee are working together operators, mine workers, rescue men and mine inspectorates. The main advantage of this committee is not the papers, we are getting too much paper from this community, it is impossible to read and study it. But there is a similar

advantage, in my opinion, as in this symposium. You come in contact with persons who have the same responsibility, and you know them personally and therefore the information is exchanged very quickly. For example, from my colleague, Mr. Cariven, who works in the same committee, I may know the details of a small mine fire earlier than some other colleagues and the same works with the United Kingdom and the other countries. We work very close together across the border to the east. We exchange our experiences in a very fast and uncomplicated manner.

A. Dr. P.A. Krzystolik, Poland.

In eastern Europe we have a parallel system of formal and informal information exchange. The various rescue station representatives are in fact currently meeting in Southern Bulgaria.

CLOSING REMARKS BY

J. J. GRAHAM
British Mining Consultants Limited

Gentlemen, I think that perhaps this might be a suitable time to draw the proceedings to a close. It is always difficult to summarise when the excellent papers presented to this symposium have covered each topic in such a thorough and comprehensive manner. Before summarising, however, I would like to thank everyone who had participated in this closing open forum. The authors have again demonstrated their skills in dealing with a wide range of questions which have been presented by a stimulating audience.

In summarising the whole conference, I would like to touch on some of the main points on which most of us will reflect, and act, in the months and years to come.

1. Crisis management has been with us for a very long time and regrettably it will not disappear. Hopefully, it will be called into use less frequently in the years to come. If this is to happen, everyone in the mining industries, in all continents, will have to play their part. Operational management, rescue workers, research personnel, inspectors of mines and the complete work force will have their part to play.

2. I believe that we have got to ensure that our training systems, for everyone working in our mines, are thorough and that we keep them up-dated. We must cover, with different types of training, the different requirements of the work force, junior management and senior management. Those selected for rescue work must similarily get the best possible training and we must ensure that they are supplied with the latest equipment. Only by doing this can we ensure that when incidents do occur, our rescue people will be more effective.

3. From points made during the last few days, it appears that certain European countries seem to be moving to have rules and codes of practice which will be in common use. I have detected that in Canada the provincial requirements dominate. I do not suggest for one moment that the rules and codes of practice for dealing with crisis management differ greatly between Nova Scotia, Alberta or British Columbia, but with movement of staff during crisis, even in a country the size of Canada, there would be real merit in having one common code of practice throughout Canada. Perhaps one day this will be a reality. The same could perhaps be said of Australia.

4. A great deal has been said about the organisation of any rescue operation and this appears to differ from country to country. The relationship between the mine manager, the rescue superintendent and the inspector of mines has been discussed frequently during the last three days. Certain delegates to this symposium have stated that the mine manager should always remain in charge, others have stated that, as he could be emotionally involved, another engineer should be appointed to be in overall charge of the whole operation. I personally believe that the mine manager should remain in charge as he should know the detailed workings of his mine better than most people.

At the fresh air base, Mr. Strang from Australia was quite adamant that the senior rescue superintendent should be in charge of the fresh air base and not a local mine official. It also became clear during the symposium that the rescue operation varied in different countries depending on whether you were dealing with large or small mines, whether the mines were in close proximity or remote from each other, as this affects the location, size and staffing of specialist rescue teams. Dr. Krzystolik from Poland presented the case for a complete team of specialist engineers, in all disciplines, moving to a mine and working alongside the equivalent engineers. Mr. Bob Peluso dealt in geat detail with the specialist American Team who are available to respond to a crisis call from any part of the U.S.A.

5. Communication during crisis brought forth a number of interesting comments. A number of speakers and delegates referred to improved telephone systems being installed in mines and there were some interesting comments on the use of intrinsically safe 2-way radios and the like. Mr. Kock from Germany also made a point about having a telephone line underground that can only be used for sending messages out of the mine to the surface.

6. The topic which, to me, appears to have made the greatest strides in the last four or five years is the whole question of monitoring of mine atmospheres. This subject has been referred to many times because of its importance in early detection of dangerous occurrences. The use of the Corex Tube Bundle system to remotely monitor mine atmospheres automatically at the surface is a great step forward. The use of the new technique ensures a great saving in time with regard to sampling and analysing mine atmospheres and, equally important, the automatic instantaneous read-out information on the surface can be relayed back underground to rescue teams to help them to plan their strategy for dealing with the dangerous occurrence.

7. Major fires arising from spontaneous heatings have been dealt with, and this is an important problem which has affected every coal mining country in the world at some time in the past. It appears that the new technique of using large volumes of inert gas to deal with spontaneous heatings has been most successful, particularly in Europe and U.K. It was interesting to hear that the machinery for producing inert gas has recently been delivered to the USA and is shortly to be evaluated by research personnel. I feel confident that the use of inert gas as a technique will spread to all parts of the world as it has been proved to be so successful in bringing spontaneous heatings/ fires under control. Some comments were made at the Open Forum this morning concerning the high capital cost of installing a modern, high productivity longwall face in a coal mine and this can vary between US $ 5 and 8 million. The use of the inert gas technique has already demonstrated that fires can be controlled whereas, in previous years, sealing off inevitably resulted in the loss of both production and costly capital equipment.

8. Comment was made about the development of equipment for drilling large diameter holes to effect rescues when men are cut off in remote parts of a mine. It is always possible that this technique might one day be the only means of getting men to the surface. The location of these special drill units must be such that they can be brought quickly to any mine which needs them during an emergency. The siting of the equipment, so that any hole drilled from the surface will intersect a small underground roadway presents special problems, and although it is a technique that has seldom been used in the last 10 years, it is one that we must always acknowledge could play a vital part in a rescue in certain selected conditions.

9. The new technologies which have been mentioned in many of the papers at this symposium are all being developed with a view to reducing the number of incidents which result in the need for crisis management. Mr. Kock from Germany used some statistics and pointed out that there had been 838 incidents during the last 20 years in Germany. Mr. C. Gorrie from the UK, stated that in the last 15 years, following the general introduction of self-rescuers in British coal mines, there had been no fatalities associated with underground fires, whereas in the fifteen years prior to their introduction, there had been about 150 fatalities. It would be helpful, when the papers from this symposium are published, if the authors could indicate with some statistics how new technology has improved safety in their particular country.

10. The question of improved training of all staff who work at mines, both underground and on the surface, has been mentioned. Apart from adequate training coupled with good mining practice, the question of good mine planning, the selection of the right mining method and equipment can also play an important part in reducing the incidents which lead to crisis management.

11. Frequent reference has been made to dangerous incidents which have stemmed from auxiliary ventilation units. Some form of auxiliary ventilation is in use in most mines and it is vital that the use of fans should be strictly controlled and competent specialist mine ventilation engineers should be involved when they are introduced into any mine.

12. I would like to conclude by thanking Mr. Ab Oliver and his organising committee for having had the foresight to organise this symposium. The fact that it has been truly international has enhanced its value and the quality of all the papers presented will be more fully appreciated when they are published. Bearing in mind that the Cape Breton management were involved in a crisis due to a serious underground fire last week, everyone locally is to be congratulated as the incident was brought quickly under control and it did not prevent this symposium starting on time.

The atmosphere throughout this symposium has been excellent. Whenever you get mining men together, either in individual countries or at an international gathering such as this, the rapport is excellent. However, bearing in mind that only a small portion of the mining fraternity in any country is trained in mines rescue work, they form a special small elite group of people who have much in common to discuss whenever they meet.